CHEMICAL COMPOSITIONS THAT ATTRACT ARTHROPODS

claim 2

BACKGROUND OF THE INVENTION

Insects have plagued people throughout history. Fast intercontinental travel and trade have enabled the importation of nonindigenous insect pests (e.g., species of mosquitoes, such as *Aedes albopictus*, the Asian Tiger mosquito) into the United States. As a result, the U.S. must face the task of controlling numerous species of nuisance pests, such as arthropods and, more specifically, mosquitoes. Some of these insects spread disease and, thus, are of great medical and veterinary importance. Control of these pests is necessary to reduce or eliminate the spread of arthropod-borne diseases.

The primary focus of this invention is the control or reduction of the population of mosquitoes. At least three "generations" of control methods have been developed over the years. The first generation of control methods comprise chemicals dispensed by foggers or sprayers, both on the ground and through the air. These chemicals may be classified as either adulticides or larvicides and are intended to attack and kill the adult mosquito or its larva, respectively. These chemicals usually have an inherent toxicity, which is potentially injurious to the environment, to marine life and wildlife, and ultimately to humans. As a result, these chemical insecticides have become viewed with disfavor.

One such insecticide product was "DURSBAN™ 10CR" produced by Dow Chemical Company in the mid-1970's. There were at least two problems with this product. First, it was inherently toxic and potentially harmful to the environment. Second, because of rapid turnover of the mosquito population and the selection of resistant genes by Dursban, insects could develop a resistance to the chemicals. Mosquitoes ultimately develop an immunity to adulticides of the same chemical family. This situation is referred to as "cross resistance" and illustrates that under adverse conditions, insects may adapt. This ability to adapt, often within a few generations, provides complications for researchers engaged in the field of pest control.

As a departure from the chemical adulticides and larvicides, a second generation of mosquito control product was developed. This second generation is known as insect growth regulators. Their purpose is to prevent the immature insect from transforming into an adult. This class of mosquito control product allows the larva to enter into its pupa stage but prevents the pupa from developing into an adult. These products have very low toxicity, or practically no toxicity, and hence are not detrimental to aquatic life. Due to the general application of this control material to the environment through a form such as a charcoal briquet, the products are messy, inconvenient to handle, and are very expensive. These products also require adequate surveillance of standing water and delivery of briquets to these locations. The potential exists that some sites will go untreated.

Over the past fifteen years, a third generation of insecticides has been developed. These are bacteriological methods for spreading endotoxins among insect populations. One of the most successful endotoxin agents used against insects is *Bacillus thuringiensis* Berliner var. *kurstaki*, a bacterium which infects the larvae of Lepidoptera (moths) that are to be destroyed. More recently, a new variety has been uncovered for use against mosquito and black fly larvae. This is *Bacillus thuringiensis* Berliner var. *israelensis* and its accompanying proteinaceous parasporal particles which contain protoxin. When a larvicidal microorganism of the bacillus type is used and is sprayed on the water in the form of a liquid produced by diluting the wettable powder or liquid concentrate with water, a similar problem is encountered. The bacillus spores and protoxin particles are heavier than water and sink. Additionally, the application of the bacillus does not have a sustained release – it is essentially "one shot" – and hence re-applications are often necessary to insure an effective mosquito control program. This is time consuming and expensive, and extensive surveillance is needed to target all breeding areas.

Besides these existing chemical and microbial insecticides, other devices and methods are known for the control or destruction of mosquitos and other aquatic pests.

U.S. Letters Pat. Nos. 4,166,112 and 4,187,200, issued to Goldberg in 1979 and 1980, respectively, disclosed *Bacillus thuringiensis* in which a carrier was formulated as a buoyant colloidal suspension which stabilized just under the surface of the water.

According to information published by Biochem Products, a division of Salsbury Laboratories, Inc., a member of the Solvay Group, the earliest documented record of *Bacillus thuringiensis* was in Japan in 1901. In the decades since, at least 14 varieties of *B.t* have been identified from several countries on the bases of biochemical characteristics and serotyping of vegetative cell flagellar antigens. *Bacillus thuringiensis*, Berliner also known as HD-1, Serotype H-*3a3b*, or *B.t.* variety *kurstaki*, has been registered in the United States since 1961 for control of Lepidopteran larvae or caterpillars and is the type commonly used in forestry, agriculture, home and commercial gardening and horticulture. Products containing *B.t* reportedly have an excellent safety record with no documented incidents of serious or undesirable side effects on man and the environment. Biochem Products supplies a wettable powder or a flowable concentrate under the trademark "BACTIMOS™" which is derived from *B.t.i.*, Serotype H-14, *Bacillus thuringiensis* variety *israelensis,* and was discovered in Israel in 1976. This is a larvicidal microorganism comprising *Bacillus thuringiensis* Berliner var. *israelensis* and its accompanying proteinaceous parasporal particles which contain protoxin (commonly referred to as "*B.t.i.*").

For mosquito control purposes, the BACTIMOS™ (*B.t.i.*) is invariably mixed with water and is applied to large areas, using airplanes or helicopters. This method of application has been continually used despite the constant and critical need for an alternate delivery system for the myriad of ponds and other small bodies of water, as recognized in MOSQUITO NEWS in 1948.

Moreover, any attempt to impregnate *B.t.i.* (or the larvicidal microorganism of the aforesaid Goldberg patents) into the floating thermoplastic carrier of the aforesaid Cardarelli patent, would be impractical (if not impossible) and would destroy the stated utility of these references. An exposure of the *B.t.i.*

particles to temperatures above 70° or 80° Celsius – depending upon the exposure time, which is inversely correlated with temperature – will cause the *B.t.i.* to suffer a protein denaturization, resulting in a change in its molecular structure and a loss of its activity. Thus, it would be impractical to attempt to incorporate *B.t.i.* into a thermoplastic or elastomeric strip of material, in view of the molding temperatures likely to be encountered. Moreover, even if the *B.t.i.* could be incorporated into a polymer or elastomeric matrix without substantially limiting or destroying its efficacy, these *B.t.i.* particles are agglomerations of relatively large molecules and are incapable of migrating within a polymer or elastomeric matrix. Hence, they would not even be released, since the active protein toxin has a molecular weight of approximately 28 megadaltons. The aforementioned methods are efficient, but are performed at high monetary costs to mosquito districts and taxpayers. Ultimately, the mosquitoes sought to be controlled are those noticed readily by humans, i.e. mosquitoes and blood-sucking flies that draw blood meals from humans.

Thus, numerous severe problems exist with the mosquito extermination methods that use chemical insecticides. As such, an alternative approach toward arthropod surveillance and control has been developed. One such promising method is the use of chemicals as attractants for mosquitoes and other arthropods that prey on human and animal hosts. The combination of highly effective chemical attractants with efficient traps allows for a control method to be developed similar to that used to control the Tsetse fly in Africa (Vale and Hall, Bull. Ent. Res., 75, 219-231 (1985)). Because effective attractants are known for the Tsetse fly, a control method using only baited traps was developed and is very effective.

Current surveillance techniques rely on light traps or other traps which are relatively inefficient in mosquito collection. Sentinel chickens are used to assess transmission risk of encephalitis to humans in a local area. Better traps via more efficient and less expensive lures or baits would greatly aid in this endeavor. One example of a trap, U.S. Patent No. 5,657,756 to Nicosia, 1997, involves collection and trapping of arthropods using warmed circulated fluid.

Carbon dioxide has been shown to attract mosquitoes. Willis, J. Exp. Zool., 121, 149-179 (1952), discloses that *Aedes aegypti* (mosquitoes) are attracted to carbon dioxide. From amputation experiments on female *Aedes aegypti*, it was discovered that carbon dioxide receptors were located on the antennae. The role of carbon dioxide in the attraction of mosquitoes to hosts also has been the subject of numerous laboratory studies. Rudolfs, N. J. Agric. Exp. Sta. Bull., 367 (1922), and Gouck, J. Econ. Entomol., 55, 386-392 (1962), describe carbon dioxide as an activator, rather than an actual attractant.

Acree, Science, 1346-7 (1968), discloses that L-lactic acid, isolated from the human hand, attracts female *Aedes aegypti*. It also discloses that carbon dioxide is necessary to observe this attraction.

Wensler, Can. J. Zool., 50, 415-420 (1972), discloses the use of ethyl ether soluble honey odors to attract *Ae. aegypti*.

Compositions consisting of lactic acid analogues and carbon dioxide have also been shown to attract mosquitoes. Carlson, J. Econ. Entomol., 66, 329-331 (1973), discloses that some tested analogues of lactic acid had equivalent attraction to L-lactic acid, but this was not true at all tested doses. The highest reported attraction was 40% of female *Ae. aegypti*.

Bar-Zeev, J. Med. Entomol., 14, 113-20 (1977), discloses that a composition consisting solely of lactic acid and carbon dioxide attracts *Ae. aegypti*. Here, the lactic acid was dissolved in acetone, similar to the use of methanol for the invention described in this application. It is clearly stated that the acetone solvent was evaporated from the filter paper prior to the carbon dioxide being allowed to pass into the flask. Acetone was chosen for its properties as a solvent, i.e., good ability to dissolve L-lactic acid and high volatility resulting in rapid evaporation or drying.

Price, J. Chem. Ecol., 5, 383-95 (1979), discloses that human emanations and carbon dioxide attract female *An. quadrimaculatus*.

Lactic acid was shown to attract mosquitoes such as virgin *Ae. aegypti* (mosquitoes) by Davis, J. Insect Physiol., 30, 211-15 (1984).

Gillies, Bull. Entomol. Res., 70, 525-32 (1980), reviews the use of carbon dioxide to activate and attract mosquitoes.

Schreck, J. Chem. Ecol., 8, 429-38 (1981), discloses that materials isolated from human hands, other than L-lactic acid, attract female *Ae. aegypti* and *An. quadrimaculatus* mosquitoes.

Lactic acid, in combination with phosphorous-containing compounds have been shown to attract mosquitoes. Ikeshoji, Jpn. J. Sanit. Zool., 38, 333-38 (1987), discloses lactic acid and hempa; lactic acid and metepa; lactic acid, metepa and olive oil; and lactic acid and DDVP attract mosquitoes.

Lactic acid-related compounds have also been tested as mosquito attractants by electrophysiology. Davis, J. Insect Physiol., 34, 443-49 (1988), discloses that neurons in the antennae are excited by L-lactic acid, and that analogues of lactic acid, e.g., carboxylic acids, alcohols, hydroxyacids, aldehydes, thiols and haloacids were tested for neuron response. It was shown that no compound elicited as high of a relative responsiveness toward lactic acid-excited cells as did lactic itself.

It has been shown that carbon dioxide, in combination with other chemicals, serves as an attractant for mosquitoes. Takken and Kline, J. Am. Mosq. Control Assoc., 5, 311-6 (1989), disclose 1-octen-3-ol (octenol) and carbon dioxide as mosquito attractants. Van Essen, Med. Vet. Entomol., 63-7 (1993), discloses the use of carbon dioxide, octenol, and light to attract several species of mosquitoes. Takken, J. Insect Behavior, 10, 395-407 (1997), discloses that a composition consisting solely of carbon dioxide, acetone and octenol attracts several species of mosquitoes.

Kline, Med. Vet. Entomol., 4, 383-91 (1990), discloses that honey extract, octenol, carbon dioxide, L-lactic acid plus carbon dioxide, L-lactic acid plus octenol plus carbon dioxide attract mosquitoes well and butanone plus carbon dioxide, and phenol alone are less effective.

Schreck, J. Am. Mosq. Control Assoc., 6, 406-10 (1990), discloses that materials isolated from human skin attract female *Ae. aegypti* and *An.*

quadrimaculatus (mosquitoes), and the level of attraction, transferred to glass, varies from person to person. It also discloses that differences in attraction level are present depending on the body location origin of the material.

Takken, Insect Sci. Applic., 12, 287-95 (1991), reviews mosquito attractants and lists acids, alone or in combination with other amino acids that are attractive for mosquitoes.

Eiras, Bull. Entomol. Res., 81, 151-60 (1991), discloses that lactic acid, carbon dioxide, human sweat and thermal convection currents attract female *Ae. aegypti.*

Carlson, J. Med. Entomol., 29, 165-70 (1992), discloses that the release of carbon dioxide from the human hand is negligible and therefore is not a factor in the attraction of *Ae. aegypti* (mosquitoes) to the human hand.

Bowen, J. Insect Physiol., 40, 611-15 (1994), discloses that lactic acid sensitive receptors are present in *Ae. atropalpus*.

Eiras, Bull. Entomol. Res., 84, 207-11 (1994), discloses that lactic acid in combination with carbon dioxide has been shown to attract mosquitoes.

Charlwood, Ann. Trop. Med. Parasitol., 89, 327-9 (1995), discloses the mosquito-mediated attraction of female mosquitoes to hosts. Several species of mosquitoes were more attracted to a host, e.g., human leg, which already had mosquitoes feeding than a host which had no mosquitoes feeding on the host (termed "invitation effect"). An apparent pheromone, which was given off by the feeding mosquitoes, was speculated to attract other mosquitoes to the host.

DeJong and Knols, Experientia, 51, 80-4 (1995), discloses that different malaria mosquito species (*An. gambiae* s.s. and *An. atroparvus*) prefer different biting sites on the human body. DeJong and Knols, Acta Tropica, 59, 333-5 (1995), disclose that *An. gambiae* is attracted to carbon dioxide.

Bernier, Ph.D. Dissertation, University of Florida (1995), discloses the presence of lactic acid, glycerol, and long chain acids and alcohols on the skin, as well as other chemicals for a total of over 300 compounds. Some of these were identified and examined as candidate attractants.

Geier, in Olfaction in Mosquito-Host Interactions, 132-47 (1996), discloses that carbon dioxide alone is an attractant and that lactic acid alone is a mild attractant, but that the two act as a synergistic attractant. It also discloses that fractions of ethanol washings from human skin are attractive.

Knols and DeJong, Parasitol. Today, 12, 159-61 (1996), disclose that carbon dioxide in combination with Limburger cheese, serves as an attractant for female *An. gambiae*. It was suggested that mosquitoes are attracted to odors emanating from feet and ankles and this odor resembles Limburger cheese. It was also suggested that the odor of Limburger cheese was due to bacteria involved in cheese production which originate in human skin; cornyeform bacteria, in particular strains of *Brevibacterium linens*, which is closely related to *Br. epidermidis*, which forms part of the normal microflora of human feet, methanethiol, a pungent sulfur compound which is metabolized from L-methionine liberated during proteolytic activity and reported to contribute substantially to both cheese and foot odor; or the significant quantities of short-chained fatty acids in Limburger cheese.

McCall, J. Med. Entomol., 33, 177-9 (1996), discloses that *Ae. aegypti* (mosquitoes) were attracted to volatile constituents of mouse odor, but did not identify potential chemicals.

Knols, Bull. Entomol. Res., 87, 151-9 (1997), discloses the use of Limburger cheese (the acid and non-acid solvent extracted fractions) to attract *An. gambiae* (mosquitoes). Nineteen saturated and unsaturated aliphatic fatty acids, ranging in carbon chain lengths from C_2-C_{18} were identified in Limburger cheese.

Mboera, J. Vector Ecol., 23, 107-13 (1998), disclosed that *Culex quinquefasciatus* is attracted to a worn stocking and that carbon dioxide plus body odor did not increase response.

Kline, J.Vector. Ecol., 23, 186-94 (1998), disclosed that in olfactometer tests, the human hand or worn sock attracted 80% and 66%, respecively, of *Ae. aegypti* in the cage. In comparison, Limburger cheese attracted 6.4%, and the control 0.0% in the olfactometer.

Bernier, Anal. Chem., 71, 1-7 (1999), discloses the method for analysis of skin emanations, including the identification of lactic acid, glycerol, C_{12}-C_{18} carboxylic acids and C_4-C_{11} aldehydes.

Takken and Knots, Annu. Rev. Entomol., 44, 131-57 (1999), reviewed odor-mediated behavior of afrotropical mosquitoes, reaffirming carbon dioxide as the best known mosquito kairomone.

Braks and Takken, J. Chem. Ecol., 25, 663-72 (1999), disclose that 2-day-old incubated sweat became attractive to *An. gambiae*.

Various chemicals have been disclosed as attractants for mosquitoes. U.S. Patent 4,818,526 to Wilson discloses the use of dimethyl disulfide and dibutyl succinate and combinations thereof as attractants for Culicidae (mosquitoes).

U.S. Patent 4,907,366 to Balfour (1990) discloses the use of a composition consisting solely of lactic acid, carbon dioxide, water, and heat to attract mosquitoes.

PCT WO 98/26661 to Justus discloses mixtures of L-lactic acid and its sodium salt, glycerol, and cheese extracts, with and without unsaturated long chain carboxylic acids, alcohols and an amide as attractive for *Ae. aegypti*. The glycerol, as well as other components described as equivalent to the glycerol, appear to make the composition substantive, so that it does not evaporate immediately in a rapid pulse. However, the active ingredients from Limburger cheese, which are the attractant chemicals, are not disclosed within the document, nor were statistical data reported for the results used in the examples.

Several of the above-mentioned chemicals and chemical compositions have been employed to attract any of the hundreds of species of mosquitoes and related arthropods that utilize humans and animals as their hosts. In fact, many of the disclosed compositions have been claimed to be active as attractants for mosquitoes. The activities of these attractants are often inconsistent and below 50% attraction response in laboratory experiments. More specifically, none of the disclosed compositions have been able to attract mosquitoes on a consistent basis as efficiently as, or more efficiently than the human body. As such,

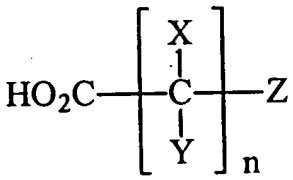
the human body has been examined repeatedly to provide clues regarding the chemical compositions disclosed. Thus, while chemicals and chemical compositions may have been active in attracting mosquitoes, none have been classified as successful for mosquito attraction as those reported in this document.

A long-felt need therefore exists for chemical compositions that can be employed safely in the environment, and that exhibit a synergistic effect for attracting mosquitoes wherein the compositions are more efficient than the human body in attracting mosquitoes. The present invention satisfies this need. Current mosquito traps often use carbon dioxide, which in the prior art was needed for efficient collection and surveillance. The present invention obviates the need for large carbon dioxide gas cylinders or dry ice by providing mosquito attractants that perform as well as, and more efficiently in place of, carbon dioxide. Although carbon dioxide is not necessary, it can still be included to release blends, as some insects may be attracted only with its inclusion.

SUMMARY OF THE INVENTION

The present invention provides compositions that efficiently attract arthropods (e.g., mosquitoes). Accordingly there is provided a composition comprising:

(A) an effective amount of at least one compound of formula I



Formula I

wherein each X is independently H, halogen, OH, SH, oxo, or (C_1-C_8)alkyl group;

each Y is independently H or (C_1-C_8)alkyl group,

Z is H, OH, SH, COOH, or (C_1-C_8)alkyl group;

n is an integer between 1 and 10, inclusive;

and salts thereof; and

an effective amount of at least one compound from group II wherein group II compounds include a ketone having 3-10 carbon atoms, carbon dioxide, (C_2-C_{10})alkene, (C_1-C_{10})aldehyde, an alcohol having 1-8 carbon atoms, a halogenated compound containing 1-8 carbon atoms, a nitrile containing 2-4 carbon atoms, an ether containing 3-10 carbon atoms, (C_6-C_{10})aryl group, a sulfide containing 1-8 carbon atoms and (C_3-C_{10})heterocyclic group;

wherein any one or more of the (C_6-C_{10})aryl group or (C_3-C_{10})heterocyclic group may be substituted at any one or more positions with a substituent selected from the group consisting of H, oxo, halogen, OH, SH, COOH, $COO(C_1-C_8)$alkyl group, (C_1-C_8)alkyl group, (C_1-C_8)alkyl sulfide and (C_1-C_8)alkyl group;

and salts thereof;

wherein the composition is effective to attract arthropods; or

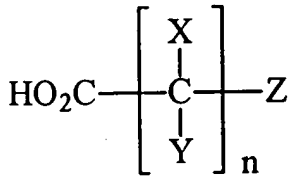
(B) a composition comprising an effective amount of tartaric acid or an acceptable salt thereof; and

an effective amount of at least one compound from group II wherein group II compounds include a ketone having 3-10 carbon atoms, (C_2-C_{10})alkene, (C_1-C_{10})aldehyde, an alcohol having 1-8 carbon atoms, a halogenated compound containing 1-8 carbon atoms, a nitrile containing 2-4 carbon atoms, an ether containing 3-10 carbon atoms, carbon dioxide, (C_6-C_{10})aryl group, a sulfide containing 1-8 carbon atoms and (C_3-C_{10})heterocyclic group;

wherein any one or more of the (C_6-C_{10})aryl or (C_3-C_{10})heterocyclic may be substituted at any one or more positions with a substituent selected from the group consisting of H, oxo, halogen, OH, SH, COOH, $COO(C_1-C_8)$alkyl group, (C_1-C_8)alkyl group, (C_1-C_8)alkyl sulfide and (C_1-C_8)alkyl substituted with at least one substituent selected from the group consisting of H, OH, SH and halogen;

and salts thereof; wherein the composition is effective to attract arthropods; or

(C) a composition comprising an effective amount of at least one



Formula I

compound of formula I

wherein each X is independently H, halogen, OH, SH, oxo, (C_1-C_8)alkyl, or (C_1-C_8)alkyl substituted with at least one substituent selected from the group consisting of H, OH, SH and halogen;

each Y is independently H, (C_1-C_8)alkyl, or (C_1-C_8)alkyl substituted with at least one substituent selected from the group consisting of H, OH, SH and halogen, or Y is absent when X is oxo;

Z is H, OH, SH, COOH, (C_1-C_8)alkyl, or (C_1-C_8)alkyl substituted with at least one substituent selected from the group consisting of H, OH, SH and halogen;

n is an integer between 1 and 10, inclusive;

and acceptable salts thereof;

and an effective amount of at least one compound from group II wherein group II compounds include a ketone having 3-10 carbon atoms, (C_2-C_{10})alkene, (C_1-C_{10})aldehyde, an alcohol having 1-8 carbon atoms, a halogenated compound containing 1-8 carbon atoms, a nitrile containing 2-4 carbon atoms, an ether containing 3-10 carbon atoms, carbon dioxide, (C_6-C_{10})aryl group, a sulfide containing 1-8 carbon atoms and (C_3-C_{10})heterocyclic group;

and salts thereof;

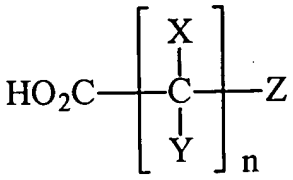
with the proviso that the compound of formula I does not consist solely of glycolic acid, oxalic acid, acetic acid, hydraacrylic acid, pyruvic acid, glyceric acid, 3-hydroxypyruvic acid, malonic acid, 3-hydroxybutyric acid, 2-methyllactic acid, 2-hydroxybutyric acid, 2-oxobutyric acid, isobutyric acid, butyric

acid, malic acid, 2-oxovaleric acid, 2-hydroxyvaleric acid, 2-hydroxyvaleric acid, valeric acid, isovaleric acid, 2-methylvaleric acid, hexanoic acid, mercaptoacetic acid, thiolactic acid, 3-mercaptopropionic acid, thiopropionic acid, 3-mercaptopropionic acid, 2-bromopropionic acid, 2-bromobutyric acid, 2-chloropropionic acid, 3-chloropropionic acid, lactic acid or formic acid;

and salts thereof;

wherein the composition is effective to attract arthropods.

The present invention provides compositions that efficiently attract arthropods (e.g., mosquitoes). Accordingly there is provided a composition



Formula I

comprising an effective amount of at least one compound of formula I

wherein each X is independently H, halogen, OH, SH, oxo, (C_1-C_8)alkyl group;

each Y is independently H, (C_1-C_8)alkyl group,

Z is H, OH, SH, COOH, or (C_1-C_8)alkyl group;

n is an integer between 1 and 10, inclusive;

and salts thereof; and

an effective amount of at least one compound from group II wherein group II compounds include a ketone having 3-10 carbon atoms, carbon dioxide, (C_2-C_{10})alkene, (C_1-C_{10})aldehyde, an alcohol having 1-8 carbon atoms, a halogenated compound containing 1-8 carbon atoms, a nitrile containing 2-4 carbon atoms, an ether containing 3-10 carbon atoms, (C_6-C_{10})aryl group, a sulfide containing 1-8 carbon atoms and (C_3-C_{10})heterocyclic group;

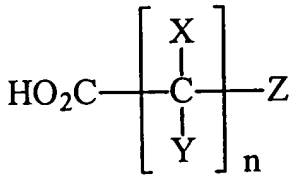
wherein any one or more of the (C_6-C_{10})aryl group or (C_3-C_{10})heterocyclic group may be substituted at any one or more positions with a

substituent selected from the group consisting of H, oxo, halogen, OH, SH, COOH, $COO(C_1-C_8)$alkyl group, (C_1-C_8)alkyl group, (C_1-C_8)alkyl sulfide, $O-(C_1-C_8)$alkyl; (C_1-C_8)alkyl group, and NR_1R_2 wherein R_1 and R_2 are each independently selected from the group consisting of (C_1-C_8)alkyl and H;

and salts thereof;

wherein the composition is effective to attract arthropods.

The present invention provides methods of attracting arthropods (e.g., mosquitoes) comprising the step of exposing the environment with a composition comprising an effective amount of a combination of:



Formula I

(A) an effective amount of at least one compound of formula I

wherein each X is independently H, halogen, OH, SH, oxo, (C_1-C_8)alkyl group;

each Y is independently H, (C_1-C_8)alkyl group,

Z is H, OH, SH, COOH, or (C_1-C_8)alkyl group;

n is an integer between 1 and 10, inclusive;

and salts thereof; and

an effective amount of at least one compound from group II wherein group II compounds include a ketone having 3-10 carbon atoms, carbon dioxide, (C_2-C_{10})alkene, (C_1-C_{10})aldehyde, an alcohol having 1-8 carbon atoms, a halogenated compound containing 1-8 carbon atoms, a nitrile containing 2-4 carbon atoms, an ether containing 3-10 carbon atoms, (C_6-C_{10})aryl group, a sulfide containing 1-8 carbon atoms and (C_3-C_{10})heterocyclic group;

wherein any one or more of the (C_6-C_{10})aryl group or (C_3-C_{10})heterocyclic group may be substituted at any one or more positions with a

substituent selected from the group consisting of H, oxo, halogen, OH, SH, COOH, $COO(C_1\text{-}C_8)$alkyl group, $(C_1\text{-}C_8)$alkyl group, $(C_1\text{-}C_8)$alkyl sulfide, $O\text{-}(C_1\text{-}C_8)$alkyl; $(C_1\text{-}C_8)$alkyl group, and NR_1R_2 wherein R_1 and R_2 are each independently selected from the group consisting of $(C_1\text{-}C_8)$alkyl and H;

and salts thereof; or

(B) a composition comprising an effective amount of tartaric acid or an acceptable salt thereof; and

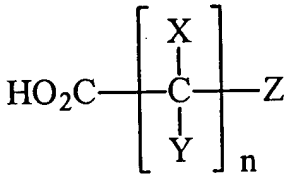
an effective amount of at least one compound from group II wherein group II compounds include a ketone having 3-10 carbon atoms, $(C_2\text{-}C_{10})$alkene, $(C_1\text{-}C_{10})$aldehyde, an alcohol having 1-8 carbon atoms, a halogenated compound containing 1-8 carbon atoms, a nitrile containing 2-4 carbon atoms, an ether containing 3-10 carbon atoms, carbon dioxide, $(C_6\text{-}C_{10})$aryl group, a sulfide containing 1-8 carbon atoms and $(C_3\text{-}C_{10})$heterocyclic group;

wherein any one or more of the $(C_6\text{-}C_{10})$aryl group or $(C_3\text{-}C_{10})$heterocyclic group may be substituted at any one or more positions with a substituent selected from the group consisting of H, oxo, halogen, OH, SH, COOH, $COO(C_1\text{-}C_8)$alkyl group, $(C_1\text{-}C_8)$alkyl group, $(C_1\text{-}C_8)$alkyl sulfide, $O\text{-}(C_1\text{-}C_8)$alkyl; $(C_1\text{-}C_8)$alkyl group, and NR_1R_2 wherein R_1 and R_2 are each independently selected from the group consisting of $(C_1\text{-}C_8)$alkyl and H;

and salts thereof;

wherein the composition is effective to attract arthropods; or

(C) a composition comprising an effective amount of at least one



Formula I

compound of formula I

wherein each X is independently H, halogen, OH, SH, oxo, (C_1-C_8)alkyl, or (C_1-C_8)alkyl substituted with at least one substituent selected from the group consisting of H, OH, SH and halogen;

each Y is independently H, (C_1-C_8)alkyl, or (C_1-C_8)alkyl substituted with at least one substituent selected from the group consisting of H, OH, SH and halogen, or Y is absent when X is oxo;

Z is H, OH, SH, COOH, (C_1-C_8)alkyl, or (C_1-C_8)alkyl substituted with at least one substituent selected from the group consisting of H, OH, SH and halogen;

n is an integer between 1 and 10, inclusive;

and acceptable salts thereof;

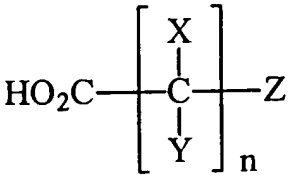
and an effective amount of at least one compound from group II wherein group II compounds include a ketone having 3-10 carbon atoms, (C_2-C_{10})alkene, (C_1-C_{10})aldehyde, an alcohol having 1-8 carbon atoms, a halogenated compound containing 1-8 carbon atoms, a nitrile containing 2-4 carbon atoms, an ether containing 3-10 carbon atoms, carbon dioxide, (C_6-C_{10})aryl group, a sulfide containing 1-8 carbon atoms and (C_3-C_{10})heterocyclic group;

and salts thereof;

with the proviso that the compound of formula I does not consist solely of glycolic acid, oxalic acid, acetic acid, hydraacrylic acid, pyruvic acid, glyceric acid, 3-hydroxypyruvic acid, malonic acid, 3-hydroxybutyric acid, 2-methyllactic acid, 2-hydroxybutyric acid, 2-oxobutyric acid, isobutyric acid, butyric acid, malic acid, 2-oxovaleric acid, 2-hydroxyvaleric acid, 2-hydroxyvaleric acid, valeric acid, isovaleric acid, 2-methylvaleric acid, hexanoic acid, mercaptoacetic acid, thiolactic acid, 3-mercaptopropionic acid, thiopropionic acid, 3-mercaptopropionic acid, 2-bromopropionic acid, 2-bromobutyric acid, 2-chloropropionic acid, 3-chloropropionic acid, lactic acid or formic acid;

and salts thereof.

The present invention provides methods of attracting arthropods (e.g., mosquitoes) comprising the step of exposing the environment with a composition comprising an effective amount of a compound of formula I



Formula I

wherein each X is independently H, halogen, OH, SH, oxo, (C_1-C_8)alkyl group;

each Y is independently H, (C_1-C_8)alkyl group,

Z is H, OH, SH, COOH, or (C_1-C_8)alkyl group;

n is an integer between 1 and 10, inclusive;

and salts thereof; and

an effective amount of at least one compound from group II wherein group II compounds include a ketone having 3-10 carbon atoms, carbon dioxide, (C_2-C_{10})alkene, (C_1-C_{10})aldehyde, an alcohol having 1-8 carbon atoms, a halogenated compound containing 1-8 carbon atoms, a nitrile containing 2-4 carbon atoms, an ether containing 3-10 carbon atoms, (C_6-C_{10})aryl group, a sulfide containing 1-8 carbon atoms and (C_3-C_{10})heterocyclic group;

wherein any one or more of the (C_6-C_{10})aryl group or (C_3-C_{10})heterocyclic group may be substituted at any one or more positions with a substituent selected from the group consisting of H, oxo, halogen, OH, SH, COOH, COO(C_1-C_8)alkyl group, (C_1-C_8)alkyl group, (C_1-C_8)alkyl sulfide, O-(C_1-C_8)alkyl; (C_1-C_8)alkyl group, and NR_1R_2 wherein R_1 and R_2 are each independently selected from the group consisting of (C_1-C_8)alkyl and H;

and salts thereof;

wherein the composition is effective to attract arthropods.

The present invention entails blends of compounds that have not been previously combined, in either volume or composition for attracting mosquitoes. The novel combination of compounds of the present invention serve as effective arthropod attractants. The novel compositions of the present invention may be more effective than humans as arthropod attractants.

It has surprisingly been discovered that the compositions of the present invention are effective in attracting arthropods, e.g., mosquitoes. In addition, it has surprisingly been discovered that compositions of the compounds of formula I and the compounds of group II exhibit a synergistic effect in attracting arthropods, e.g., mosquitoes. This synergistic effect, in many cases, enables the compositions of the present invention to attract arthropods as well as, or better than humans. In addition, the compositions of the present invention obviate the need, in many cases, for the use of carbon dioxide in arthropod traps.

DETAILED DESCRIPTION OF THE INVENTION

The following definitions are used, unless otherwise described: halo is fluoro, chloro, bromo, or iodo.

Alkyl, denotes both straight, cyclic and branched groups; but reference to an individual radical such as "propyl" embraces only the straight chain radical, a branched chain isomer such as "isopropyl" being specifically referred to.

Aryl denotes a phenyl radical or an ortho-fused bicyclic carbocyclic radical having about nine to ten ring atoms in which at least one ring is aromatic.

Heterocyclic encompasses a radical attached via a ring carbon of a monocyclic ring containing five or six ring atoms consisting of carbon and one to four heteroatoms each selected from the group consisting of non-peroxide oxygen, sulfur, and N(X) wherein each X is absent (e.g., -N=) or is H, O, (C_1-C_4)alkyl, phenyl or benzyl, as well as a radical of an ortho-fused bicyclic heterocycle of about eight to ten ring atoms derived therefrom, particularly a benz-derivative or one derived by fusing a propylene, trimethylene, or tetramethylene diradical thereto.

As is well understood in the art, substitution of compounds and groups may be highly desirable for effecting either physical (e.g., volatility, melting point, softening point, viscosity, molecular weight and size, solubility, hydrophilicity, oleophilicity, and the like) or chemical properties. Where a substituent is referred to as a "group," that term implies that the compound may be substituted or not within the practice of the present invention. Where the substituent is referred to as a moiety or without any qualification, no substitution is contemplated. For example, alkyl group is inclusive of methyl, ethyl, propyl, butyl, isopropyl, octyl, dodecyl, cyclohexyl, 1-chlorobutyl, 2-hydroxypentyl, 4-cyanobutyl, and the like. On the other hand, and alkyl moiety or an alkyl would include only such substituents as methyl, ethyl, propyl, butyl, isopropyl, octyl, dodecyl, and cyclohexyl. Similarly, reference to a material as a compound having a central nucleus of a stated formula would include any compound, with any substituent, which did not alter the bond structure of the shown formula.

It will be appreciated by those skilled in the art that compositions of the present invention will comprise one or more compounds that have one or more chiral centers. Such compounds may exist and be isolated as optically active and racemic forms. Some compounds may exhibit polymorphism. It is to be understood that the present invention encompasses any racemic, optically-active, polymorphic, or stereoisomeric form, or mixtures thereof, of a compound of the invention, that possesses the useful properties described herein, it being well known in the art how to prepare optically active forms (for example, by resolution of the racemic form by recrystallization techniques, by synthesis, from optically-active starting materials, by chiral synthesis, or by chromatographic separation using a chiral stationary phase) or using other tests which are well known in the art.

Specific and preferred values listed below for radicals, genera, chemicals, substituents, and ranges, are for illustration only and they do not exclude other defined values or other values within defined ranges for the radicals, genera, chemicals and substituents.

It is appreciated that "arthropod" is a member of the phylum Arthropoda, which is the largest phylum in the animal kingdom, comprising about 75% of all animals that have been described. The estimated number of arthropod species is between 1,000,000 and 2,000,000. Arthropods vary in size from the microscopic mites to the giant decapod crustaceans.

The phylum Arthropoda includes many families of insects that are of a medical and veterinary importance, e.g., mosquitoes (Culicidae), blackflies (Simuliidae), sand flies (Phlebotominae), biting midges (Ceratopogonidae), horseflies (Tabanidae), tsetse flies (Glossinidae), stable flies and house flies (Muscidae), fleas (Siphonaptera), lice (Anoplura), triatomine bugs (Triatominae), soft ticks (Argasidae) and hard ticks (Ixodidae).

A specific Arthropoda is mosquitoes (Culicidae), blackflies (Simuliidae), sand flies (Phlebotominae), biting midges (Ceratopogonidae), horseflies (Tabanidae), tsetse flies (Glossinidae), stable flies and house flies (Muscidae), fleas (Siphonaptera), lice (Anoplura), triatomine bugs (Triatominae), soft ticks (Argasidae) and hard ticks (Ixodidae).

It is appreciated that "mosquito" can be any of the mosquitoes belonging to the suborder diptera known as Nematocera. This suborder includes the family Culicidae. The 3400 or so species of mosquitoes are arranged in 38 genera. The Culicidae are divided into three subfamilies: the Anophelinae, including the well-known genus Anopheles, many species of which are responsible for the transmission of malaria; the Toxorhynchitinae, the large larvae of which eat other mosquito larva; and the Culicinae which, with about 2930 species in about 34 genera, are divided into two tribes: the Culicini and the Sabethini. The Culcine mosquitoes include such well known genera as Culex, Aedes and Mansonia. The sebethene mosquitoes include Sabethes, Wyeomyia and Malaya.

A specific mosquitoe is the genera Culex, Aedes, Psorophora, Wyeomyia, Mansonia, Coquilletidia or Anopheles.

A specific arthropod is a mosquito belonging to the genera Culex, Aedes, Mansonia, Wyeomyia, Psorophora, Coquilletidia or Anopholes.

Another specific arthropod is Simulidae, Triatoninae, Siphonaptera, Tabanidae, Culicoides, Phleobotomines, Muscidae, Glossinidae, Ixodidae or Argasidae.

Specifically, (C_1-C_8)alkyl can include, for example, methyl, ethyl, propyl, isopropyl, butyl, iso-butyl, sec-butyl, pentyl, sec-pentyl, iso-pentyl, hexyl, sec-hexyl, iso-hexyl, heptyl, sec-heptyl, iso-hectyl and octyl.

A specific (C_1-C_8)alkyl is methyl, ethyl, propyl, isopropyl, butyl, iso-butyl, sec-butyl, pentyl, sec-pentyl or hexyl. Another specific (C_1-C_8)alkyl is methyl. Another specific (C_1-C_8)alkyl is ethyl. Another specific (C_1-C_8)alkyl is propyl.

Specifically (C_6-C_{10})aryl, for example, can be a central nucleus comprising phenyl, indenyl or naphthyl.

A specific (C_6-C_{10})aryl is phenyl.

(C_6-C_{10})aryl may optionally be substituted at any one or more positions with a substituent selected from the group consisting of H; oxo; halogen; OH; SH; COOH; COO(C_1-C_8)alkyl; (C_1-C_8)alkyl; (C_1-C_8)alkyl sulfide; NR_1R_2 wherein R_1 and R_2 are independently selected from H and (C_1-C_6)alkyl; and (C_1-C_8)alkyl substituted with at least one substituent selected from the group consisting of H, OH, SH and halogen.

In one specific embodiment, (C_6-C_{10})aryl is substituted with CH_3 and OH. In another specific embodiment, (C_6-C_{10})aryl is substituted with CH_3. In another embodiment, (C_6-C_{10})aryl is substituted with OH. In another embodiment, (C_6-C_{10})aryl is substituted with NH_2.

Another specific (C_6-C_{10})aryl is p-cresol, benzonitrile, phenol or toluene. Another specific (C_6-C_{10})aryl is p-cresol. Another specific (C_6-C_{10})aryl is benzonitrile. Another specific (C_6-C_{10})aryl is phenol. Another specific (C_6-C_{10})aryl is toluene

(C_3-C_{10})heterocycle may be substituted at any one or more positions with a substituent selected from the group consisting of H, oxo, halogen, OH, SH, COOH, COO(C_1-C_8)alkyl, (C_1-C_8)alkyl, (C_1-C_8)alkyl sulfide and (C_1-C_8)alkyl

substituted with at least one substituent selected from the group consisting of H, OH, SH and halogen.

In one embodiment, (C_3-C_{10})heterocycle is substituted with CH_3.

A specific (C_3-C_{10})heterocycle is furan, azole, dioxane, thiophene, thiazole or triazole.

A specific (C_3-C_{10})heterocycle is furan.

Specifically, X is H, halogen, OH, SH, oxo, (C_1-C_8)alkyl, or (C_1-C_8)alkyl substituted with at least one substituent selected from the group consisting of H, OH, SH and halogen.

A specific X is H. Another specific X is halogen. Another specific X is OH. Another specific X is SH. Another specific X is oxo. Another specific X is (C_1-C_8)alkyl. Another specific X is (C_1-C_8)alkyl substituted with at least one substituent selected from the group consisting of H, OH, SH and halogen. Another specific X is CH_3.

Specifically, Y is H, (C_1-C_8)alkyl, or (C_1-C_8)alkyl substituted with at least one substituent selected from the group consisting of H, OH, SH and halogen, or Y is absent when X is oxo.

A specific Y is H. Another specific Y is (C_1-C_8)alkyl. Another specific Y is (C_1-C_8)alkyl substituted with at least one substituent selected from the group consisting of H, OH, SH and halogen. Another specific Y is Y being absent.

Specifically, Z is H, OH, SH, COOH, (C_1-C_8)alkyl, or (C_1-C_8)alkyl substituted with at least one substituent selected from the group consisting of H, OH, SH and halogen.

A specific Z is H. Another specific Z is OH. Another specific Z is SH. Another specific Z is COOH. Another specific Z is (C_1-C_8)alkyl. Another specific Z is (C_1-C_8)alkyl substituted with at least one substituent selected from the group consisting of H, OH, SH and halogen.

Specifically, n is an integer between 1 and 10, inclusive.

A specific value for n is 1. Another specific value for n is 2. Another specific value for n is 3. Another specific value for n is 4. Another specific

value for n is 5. Another specific value for n is 6. Another specific value for n is 7. Another specific value for n is 8. Another specific value for n is 9. Another specific value for n is 10.

The volatile component of skin extracts or hair extracts is the washings of skin or the washings of the shavings of hair, each blended with acetone or another suitable solvent. Although such washings of human skin or hair are not novel, the use of hair, saved hair or skin from an appropriate device not employing a shave cream can be mixed, or suspended in a suitable solvent as means to extract and release compounds attractive to arthropods. Many of the compounds found on hair are present due to skin oils, and in fact, shavings consist of both hair and dead skin cells. The same volatiles identified in Bernier, Ph.D. dissertation, University of Florida, 1995; and Bernier, et al., Analytical Chemistry, Vol. 71, No. 1, January 1, 1999 are present on the hair and dead skin cells.

Compounds of formula I will contain at least one carboxylic acid group. Particular carboxylic acids for use in the present invention include lactic acid, glycolic acid, thiolactic acid and tartaric acid.

A specific compound of formula I is lactic acid. Another specific compound of formula I is glycolic acid. Another specific compound of formula I is thiolactic acid. Another specific compound of formula I is tartaric acid.

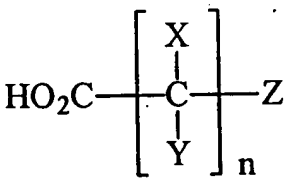
The chain lengths on the alkyl groups in formula I, particularly those inclusive of the alcohols and ketones, are important because of the need for effective levels of volatility for the individual and mixed compounds of the compositions of the invention. If significantly higher molecular weight ketones (e.g., greater than or equal to ten carbon atoms) or significantly higher molecular weight alcohols were used, the compounds and their mixtures would have reduced volatility and would not be effective, particularly over a wide area, as the compounds would not volatilize in sufficient amounts to be effective attractants over a significantly wide area. Thus, it is not likely that the higher molecular weight compounds will exhibit a synergistic effect because only one compound will be relatively volatile.

A specific compound of formula I is tartaric acid or an acceptable salt thereof. In such embodiment, the present invention is a composition comprising a combination of tartaric acid or an acceptable salt thereof; and at least one compound from group II wherein group II compounds include a ketone having 3-10 carbon atoms, (C_2-C_{10})alkene, (C_1-C_{10})aldehyde, carbon dioxide, an alcohol having 1-8 carbon atoms, a halogenated compound containing 1-8 carbon atoms, a nitrile containing 2-4 carbon atoms, an ether containing 3-10 carbon atoms, carbon dioxide, (C_6-C_{10})aryl, a sulfide containing 1-8 carbon atoms and (C_3-C_{10})heterocyclic;

wherein any one or more of the (C_6-C_{10})aryl or (C_3-C_{10})heterocyclic may be substituted at any one or more positions with a substituent selected from the group consisting of H; oxo; halogen; OH; SH; COOH; COO(C_1-C_8)alkyl; (C_1-C_8)alkyl; (C_1-C_8)alkyl sulfide; (C_1-C_8)alkyl substituted with at least one substituent selected from the group consisting of H, OH, SH and halogen; and NR_1R_2 wherein R_1 and R_2 are independently selected from the group consisting of H and (C_1-C_8)alkyl;

and salts thereof (as defined for Group I, above).

In another embodiment, the present invention is a composition comprising an effective amount of a combination of at least one compound of



Formula I

formula I

wherein each X is independently H, halogen, OH, SH, oxo, (C_1-C_8)alkyl, or (C_1-C_8)alkyl substituted with at least one substituent selected from the group consisting of H, OH, SH and halogen;

each Y is independently H, (C_1-C_8)alkyl, or (C_1-C_8)alkyl substituted with at least one substituent selected from the group consisting of H, OH, SH and halogen, or Y is absent when X is oxo;

Z is H, OH, SH, COOH, (C_1-C_8)alkyl, or (C_1-C_8)alkyl substituted with at least one substituent selected from the group consisting of H, OH, SH and halogen;

n is an integer between 1 and 10, inclusive;

and salts thereof (as defined for Group I, above);

and an effective amount of at least one compound from group II wherein group II compounds include a ketone having 3-10 carbon atoms, (C_2-C_{10})alkene, (C_1-C_{10})aldehyde, an alcohol having 1-8 carbon atoms, a halogenated compound containing 1-8 carbon atoms, a nitrile containing 2-4 carbon atoms, an ether containing 3-10 carbon atoms, carbon dioxide, (C_6-C_{10})aryl, a sulfide containing 1-8 carbon atoms and (C_3-C_{10})heterocyclic;

wherein any one or more of the (C_6-C_{10})aryl or (C_3-C_{10})heterocyclic may be substituted at any one or more positions with a substituent selected from the group consisting of H, oxo, halogen, OH, SH, COOH, COO(C_1-C_8)alkyl, (C_1-C_8)alkyl, (C_1-C_8)alkyl sulfide and (C_1-C_8)alkyl substituted with at least one substituent selected from the group consisting of H, OH, SH and halogen;

and salts thereof (as defined for Group I, above);

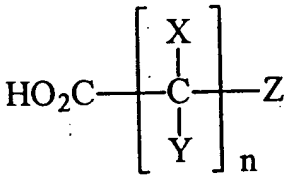
with the proviso that the compound of formula I does not consist solely of glycolic acid, oxalic acid, acetic acid, hydraacrylic acid, pyruvic acid, glyceric acid, 3-hydroxypyruvic acid, malonic acid, 3-hydroxybutyric acid, 2-methyllactic acid, 2-hydroxybutyric acid, 2-oxobutyric acid, isobutyric acid, butyric acid, malic acid, 2-oxovaleric acid, 2-hydroxyvaleric acid, 2-hydroxyvaleric acid, valeric acid, isovaleric acid, 2-methylvaleric acid, hexanoic acid, mercaptoacetic acid, thiolactic acid, 3-mercaptopropionic acid, thiopropionic acid, 3-mercaptopropionic acid, 2-bromopropionic acid, 2-bromobutyric acid, 2-chloropropionic acid, 3-chloropropionic acid, lactic acid or formic acid;

and salts thereof (as defined for Group I, above);

wherein the composition is effective to attract mosquitoes.

In the above embodiment, the compound of formula I includes one or more (e.g., 1, 2, or 3) compounds selecetd from the group consisting of glycolic acid; oxalic acid; acetic acid; hydraacrylic acid; pyruvic acid; glyceric acid; 3-hydroxypyruvic acid; malonic acid; 3-hydroxybutyric acid; 2-methyllactic acid; 2-hydroxybutyric acid; 2-oxobutyric acid; isobutyric acid; butyric acid; malic acid; 2-oxovaleric acid; 2-hydroxyvaleric acid; 2-hydroxyvaleric acid; valeric acid; isovaleric acid; 2-methylvaleric acid; hexanoic acid; mercaptoacetic acid; thiolactic acid; 3-mercaptopropionic acid; thiopropionic acid; 3-mercaptopropionic acid; 2-bromopropionic acid; 2-bromobutyric acid; 2-chloropropionic acid; 3-chloropropionic acid; lactic acid and formic acid, in addition to one or more (e.g., 1, 2, or 3) compounds of formula I. It is appreciated that the compound of formula I may comprise two or more distinct compounds. In addition, one (or more) of the two or more distinct compounds of formula I may be one of the above-identified compounds. Moreover, any combination of the above-identified compounds is acceptable.

In another embodiment, the present invention provides a composition comprising an effective amount of a combination of at least one compound of formula I



Formula I

wherein each X is independently H, halogen, OH, SH, oxo, (C_1-C_8)alkyl, or (C_1-C_8)alkyl substituted with at least one substituent selected from the group consisting of H, OH, SH and halogen;

each Y is independently H, (C_1-C_8)alkyl, or (C_1-C_8)alkyl substituted with at least one substituent selected from the group consisting of H, OH, SH and halogen, or Y is absent when X is oxo;

Z is H, OH, SH, COOH, (C_1-C_8)alkyl, or (C_1-C_8)alkyl substituted with at least one substituent selected from the group consisting of H, OH, SH and halogen;

n is an integer between 1 and 10, inclusive;

and salts thereof (as defined for Group I, above);

and an effective amount of at least one compound from group II wherein group II compounds include a ketone having 3-10 carbon atoms, carbon dioxide, (C_2-C_{10})alkene, (C_1-C_{10})aldehyde, an alcohol having 1-8 carbon atoms, a halogenated compound containing 1-8 carbon atoms, a nitrile containing 2-4 carbon atoms, an ether containing 3-10 carbon atoms, (C_6-C_{10})aryl, a sulfide containing 1-8 carbon atoms and (C_3-C_{10})heterocyclic;

wherein any one or more of the (C_6-C_{10})aryl or (C_3-C_{10})heterocyclic may be substituted at any one or more positions with a substituent selected from the group consisting of H, oxo, halogen, OH, SH, COOH, COO(C_1-C_8)alkyl, (C_1-C_8)alkyl, (C_1-C_8)alkyl sulfide and (C_1-C_8)alkyl substituted with at least one substituent selected from the group consisting of H, OH, SH and halogen;

and salts thereof (as defined for Group I, above);

wherein the composition is effective to attract mosquitoes.

Specifically, "ketone" is any compound containing one or more -C(C=O)C- groups. Particular ketones for use in the present invention will have between 3-10 carbon atoms, inclusive. More specifically, ketone can be acetone, butanone, 2-pentanone, 2-hexanone, 2-heptanone, 3-pentanone, 3-hexanone, 3-heptanone, 4-heptanone, 5-nonanone, 3-methyl-2-butanone, 4-methyl-2-pentanone, 3-penten-2-one, 3-buten-2-one, 3-hydroxy-2-butanone, 2, 3-butanedione or 2, 4-pentanedione.

A specific ketone is acetone. Another specific ketone is butanone. Another specific ketone is 2-pentanone. Another specific ketone is 2-hexanone.

Another specific ketone is 2-heptanone. Another specific ketone is 3-pentanone. Another specific ketone is 3-hexanone. Another specific ketone is 3-heptanone. Another specific ketone is 4-heptanone. Another specific ketone is 5-nonanone. Another specific ketone is 3-methyl-2-butanone. Another specific ketone is 4-methyl-2-pentanone. Another specific ketone is 3-penten-2-one. Another specific ketone is 3-buten-2-one. Another specific ketone is 3-hydroxy-2-butanone. Another specific ketone is 2, 3-butanedione. Another specific ketone is 2, 4-pentanedione.

Specifically, "alkene" is any compound containing at least one C=C group. Particular alkenes for use in the present invention contain between 2 and 10 carbon atoms, inclusive. Particular alkenes for use in the present invention include aliphatic or cyclic alkenes. In addition, particular alkenes for use in the present invention include linear or branched alkenes. Particular alkenes for use in the present invention include isoprene, 1-heptene, 1-octene and 1-nonene.

A specific alkene is isoprene. Another specific alkene is 1-heptene. Another specific alkene is 1-octene. Another specific alkene is 1-nonene.

Specifically, "alcohol" is any compound containing at least one C(OH) group. Particular alcohols for use in the present invention will have between 1 and 8 carbon atoms, inclusive. Particular alcohols for use in the present invention may be aliphatic or cyclic alcohols. Particular alcohols for use in the present invention may be branched or straight chained alcohols. Particular alcohols for use in the present invention include methanol, ethanol, 1-hepten-3-ol and 1-octen-3-ol.

A specific alcohol is methanol. Another specific alcohol is ethanol. Another specific alcohol is 1-hepten-3-ol. Another specific alcohol is 1-octen-3-ol.

Specifically, (C_1-C_{10})aldehyde is a compound containing at least one C(=O)H group and between 1 and 10 carbon atoms, inclusive. Particular aldehydes for use in the present invention include formaldehyde, acetaldehyde, butyraldehyde, isobutyraldehyde, nonanal and benzaldehyde.

A specific aldehyde is formaldehyde. Another specific aldehyde is acetaldehyde. Another specific aldehyde is butyraldehyde. Another specific

aldehyde is isobutyraldehyde. Another specific aldehyde is nonanal. Another specific aldehyde is benzaldehyde.

Specifically, "halogenated compound" is any compound containing at least one C-X group wherein X is a halogen atom. The halogen may be fluorine, chlorine, bromine or iodine. It should be noted that one or more halogen atoms may be present in the halogenated compound. Particular halogenated compounds for use in the present invention include halogenated (C_1-C_8)alkyl such as methylene chloride, chloroform, carbon tetrachloride and bromoform.

A specific halogenated compound is methylene chloride. Another specific halogenated compound is chloroform. Another specific halogenated compound is carbon tetrachloride. Another specific halogenated compound is bromoform.

Specifically, "nitrile" is any compound containing at least one CN group. Particular nitriles for use in the present invention include acetonitrile, benzonitrile and phenylacetionitrile.

A specific nitrile is acetonitrile. Another specific nitrile is benzonitrile. Another specific nitrile is phenylacetonitrile.

Specifically, "ether" is any compound containing a C-O-C group. Particular ethers for use in the present invention will have between 3 and 10 carbon atoms, inclusive, particularly aliphatic compounds.

A specific ether is diethyl ether.

Specifically, "carbon dioxide" is represented by the formula CO_2. The carbon dioxide used in the present invention may exist as a gas or a solid. Carbon dioxide will normally exist as a gas at standard temperature and pressure. However, the carbon dioxide may be solid carbon dioxide, i.e., dry ice, in which case the carbon dioxide will sublime and eventually enter into the atmosphere as a gas. Alternatively, carbon dioxide may be delivered directly or indirectly from a cylinder or similar dispensing device. In such a case, the flow of carbon dioxide used may be monitored. As such, dry ice may be added to the other chemicals or carbon dioxide may be bubbled into the other chemicals from a carbon dioxide

source. It should be noted that both forms of carbon dioxide are equally effective. However, cost and convenience may necessitate that one form be used to the exclusion of the other.

Specifically, "sulfide" is any compound containing at least one C-S group. Particular sulfides for use in the present invention will contain between 1 and 10 carbon atoms, inclusive and between 1 and 3 sulfur atoms, inclusive. Particular aliphatic sulfides for use in the present invention include carbon disulfide, dimethyl sulfide, diethyl sulfide, dimethyl disulfide, diethyl disulfide, methyl propyl disulfide, ethyl vinyl sulfide, dimethyl sulfoxide and dimethyl trisulfide.

A specific sulfide is carbon disulfide. Another specific sulfide is dimethyl sulfide. Another specific sulfide is diethyl sulfide. Another specific sulfide is dimethyl disulfide. Another specific sulfide is diethyl disulfide. Another specific sulfide is methyl propyl disulfide. Another specific sulfide is dimethyl trisulfide. Another specific sulfide is ethyl vinyl sulfide. Another specific sulfide is dimethyl sulfoxide.

Specifically, "oxo" is C(=O).

In one embodiment, a composition of the present invention comprises a compound of formula I and comprises a compound of group II.

In one embodiment of the present invention, a composition comprises a compound of formula I, wherein a compound of formula I is lactic acid and the composition comprises at least three compounds of group II, which are acetone, carbon dioxide and dimethyl sulfide.

Those of skill in the art will recognize that suitable compositions are formed by combining the compound or compounds of formula I with the compound or compounds of group II. The order of addition should not effect the activity of the resulting composition. However, cost and convenience may necessitate certain compounds be added in a certain order. It was found that convenience and cost dictated that any gases employed be added to other gases or liquids. Additionally, any solids employed should be added to liquids. The resulting mixtures were used without further preparation, although mixing is optional for each mixture developed.

In cases where compounds are sufficiently basic or acidic to form stable nontoxic acid or base salts, use of the compounds as salts may be appropriate. Examples of acceptable salts are organic acid addition salts formed with acids which form an acceptable anion, for example, tosylate, methanesulfonate, acetate, citrate, malonate, tartarate, succinate, benzoate, ascorbate, α-ketoglutarate, and α-glycerophosphate. Particular inorganic salts of the present invention may also be formed, including hydrochloride, sulfate, nitrate, bicarbonate, and carbonate salts.

Acceptable salts may be obtained using standard procedures well known in the art, for example by reacting a sufficiently basic compound such as an amine with a suitable acid affording a physiologically acceptable anion. Alkali metal (for example, sodium, potassium or lithium) or alkaline earth metal (for example, calcium) salts of carboxylic acids can also be made.

Specifically, "environment" is the surrounding land, air or water (or any combination thereof). The environment (i.e., surrounding area) may contain arthropods (e.g., mosquitoes, biting midges, etc) such that an effective amount of the composition will attract a significant portion of the arthropods from the environment.

Alternatively, the environment will not contain a significant amount of arthropods such that an effective amount of the composition will ensure that the composition will attract a significant portion of the arthropods subsequently existing in the environment, from the environment. In such an embodiment, the compositions of the present invention will prophylactically remove arthropods from the environment.

The compositions of the present invention may be added, in any form, to a commercial or home-made trap to enhance the collection of the arthropod. The composition may diffuse out or away from the trap with or without a gas stream (e.g., air, carbon dioxide, etc.) as a carrier.

As used herein, a trap is a device that ensnares an arthropod. Effective traps include those disclosed in Example 10, Table 10. Suitable traps are commercially available from American Biophysics, East Greenwich, R.I; Bio Quip

Products, Gardena, CA; John W. Hock Company, Gainesville, FL; and Bio Sensory, Inc., Windham Mills Technology Center, Wilimatic, CT.

The compositions of the present invention may be delivered in vials or other sample containers. The compositions may exist as the chemical or chemicals of formula I in one vial or container, and the chemical or chemicals of the compound of group II in another separate vial or container. Alternatively, the composition may be blended together wherein the chemical or chemicals of formula I and the chemical or chemicals of the compound of group II may be blended together in one vial. The compositions, whether present in one or two vials, may optionally include a means of a controlled release.

The compositions of the present invention may be delivered in the gas phase, such as by a compressed cylinder. In addition, the composition existing in the gas phase, may optionally be mixed or unmixed with an inert carrier gas.

The efficacy of the compositions of the present invention in attracting arthropods, may be further enhanced by adding one or more of the chemical compositions of skin washings or hair washings as disclosed in Bernier, Ph.D. dissertation, University of Florida, 1995 or Bernier, et al., Analytical Chemistry, Vol. 71, No. 1, January 1, 1999.

The efficacy of the compositions of the present invention in attracting arthropods, may be further enhanced by adding one or more of light, heat and moisture.

It is appreciated that those skilled in the art recognize that the compositions of the present invention include one or compounds of the formula I and one or more compounds of group II compounds. The compound or compounds of formula I may comprise about 1% to about 99%,by weight, of the total composition. In addition, the compound or compounds of the group II compounds may comprise about 1% to about 99% of the total composition, by weight.

Effective amounts or ratios of each compound forming the resulting composition as well as effective amounts of the resulting composition will depend upon the individual compound or compounds of formula I and the individual

compound or compounds of group II. The amount of composition required for use will vary not only with the particular compounds selected but also with factors such as type of arthropod, weather conditions, the geographical area to be covered and the desired length of time in which the insects are to be attracted.

All chemicals used were purchased commercially from, e.g., Aldrich & Fluka Chemical, Milwaukee, WI, and Lancaster Synthesis, Windham, NH.

All publications and patents are incorporated by reference herein, as though individually incorporated by reference, as long as they are not inconsistent with the present disclosure. The invention is not limited to the exact details shown and described, for it should be understood that many variations and modifications may be made while remaining within the spirit and scope of the invention defined by the claims.

The invention will now be illustrated by the following non-limiting Examples, wherein unless otherwise specified, the tests were conducted with approximately 75 6-8 day old nulliparous female *Aedes aegypti.* The tests were conducted in an olfactometer (55 ft^3/min airflow, 80°F, 60% R.H.) as described by Posey, J. Med. Entomol., 35, 330-334 (1998); and LA is lactic acid. Mosquitoes were allowed to settle at least one hour prior to testing. The olfactometer was cleaned after each battery of tests. Each battery consisted of three tests, conducted at 08:30, 11:00 and 13:00 hours local time. Each of the three tests was conducted in a separate cage. The control consisted of identical sample delivery devices and conditions compared to that of the treatment side. Both the treatment and control ports were opened and closed simultaneously when inserting a new treatment/control.

EXAMPLES

Example 1

Table 1 illustrates the effectiveness (in percentage caught of 75 female mosquitos) of lactic acid alone and of acetone alone as attractants for *Aedes aegypti*. It was shown that 200 µL lactic acid alone attracted an average of 26% of

the mosquitoes. It was also shown that 500 µL acetone alone, evaporated from a 60 mm diameter glass petri dish, attracted an average of 51% of the mosquitoes.

Table 1
Compounds Screened in the Olfactometer

L-lactic acid response (%) with 200 µL of a 1 µg/1 µL methanolic solution, dried 3 minutes in a petri dish:

25	31	57	12	23	29	5	27	7	7	7	14	36
26	28	52	31	44	60	4	20	22	25	29	15	24
26	25	19	8	16	27	48	64	23	14	22	25	25
20	13	14	21	23	52	40	17	31	36	25	9	

LA Avg: 1303/51 = 26%, n = 51 trials
Acetone response (%) at 500 µL, plated on a small petri dish:

51	48	53	51

Acetone Avg: 203/4 = 51%, n = 4 trials

Example 2

Table 2 illustrates the effectiveness of several classes of compounds (e.g., ketones, carboxylic acids, alcohols, halogenated compounds, aldehydes, alkenes, nitriles, heterocyclic, sulfides, ethers, etc.) as attractants for *Aedes aegypti* mosquitoes. In addition, Table 2 also illustrates the synergistic effectiveness of these compounds with lactic acid as attractants for mosquitoes.

Table 2

Results of screening for compounds (high dose of 500 µL) with a mode of action similar to acetone are below. These compounds are also called "activators" or "activator 2" compounds where the number designation of activator denotes that those chemicals elicit different behaviors (e.g., probing, flight pattern) in attraction. Italicized numbers represent values or, when present, average values that capture greater than 50% of mosquitoes. (CK = check or control port):

Compound/CLASS	Response (%)	Response with L-LA (%)	Δ [(Resp with LA) - Resp] (%)
carbon dioxide 5 ml/min		*68*	
KETONES:			

Compound/CLASS	Response (%)	Response with L-LA (%)	Δ [(Resp with LA) - Resp] (%)
acetone	51 48 53 51 *(51%)*	87 87 86 95 85 90 92 75 86 84 88 70 82 96 88 96 88 81. 95 97 97 93 95 90 82 80 95 (88%)	37
2-butanone	28	*81*	53
2-pentanone	8	*76*	64
2-hexanone	3	*51*	48
2-heptanone	17	42	25
2-octanone	8	16	8
2-nonanone	8	12	4
2-decanone	14	24	10
3-pentanone	12	28	16
3-hexanone	1	39	38
3-heptanone	12	36	24
3-nonanone	4	9	5
4-heptanone	12	32	20
5-nonanone	14	47	33
1-penten-3-one	19	23	4
3-penten-2-one	11	49	38
3-buten-2-one	31 *61 in CK	39 *51 in CK	8
2,3-butanedione	37	29	-8
3-methyl-2-butanone	8	*82*	74
3-methyl-2-pentanone	8	9	1
2-methyl-3-pentanone	1	9	8
4-methyl-2-pentanone	0	*64*	64
6-methyl-5-hepten-2-one	9	16	27
3-hydroxy-2-butanone	11	35	24
acetophenone	9	46	37
CARBOXYLIC ACIDS:			
propanoic acid	3	1	-2
ALCOHOLS:			
methanol	10	*66*	56

Compound/CLASS	Response (%)	Response with L-LA (%)	Δ [(Resp with LA) - Resp] (%)
ethanol	9	*57*	48
p-cresol	5	32	27
1-hepten-3-ol	10	15	5
HALOGENATED:			
methylene chloride	*87*	*70 90*	-7
chloroform	24	*76*	52
carbon tetrachloride	*92*	*92*	0
bromoform	27	*64*	37
ALDEHYDES:			
formaldehyde (37%)	1	5	4
acetaldehyde	8	29	21
butyraldehyde	6	7	1
isobutyraldehyde	13	32	19
nonanal	11 10	22 21	10
benzaldehyde	9	21	12
ALKANES/ALKENES/ HYDROCARBONS:			
isoprene	12	23	11
1-heptene	5	19	14
1-octene	38	42	4
1-nonene	6	8	2
toluene	7	*59*	52
NITRILES:			
acetonitrile	27	*81*	54
benzonitrile	4	48	42
phenylacetonitrile	16	*63*	47
HETEROCYCLIC/ FURANS:			
2-methylfuran	15 *30 in CK	52	37
SULFIDES:			
carbon disulfide	*82*	*89*	7
dimethyl sulfide	32	*79*	47
diethyl sulfide	15	*54*	39

Compound/CLASS	Response (%)	Response with L-LA (%)	Δ [(Resp with LA) - Resp] (%)
ethyl vinyl sulfide	18	*55*	37
dimethyl disulfide	36	*86*	50
diethyl disulfide	33	49	16
methyl propyl disulfide	19	40	21
dimethyl trisulfide	21	*67*	46
dimethyl sulfoxide	3	30	27
ETHERS:			
diethyl ether	25	*56*	31

Example 3

Table 3 illustrates the effectiveness of analogues of lactic acid as attractants for mosquitoes. In addition, Table 3 illustrates the synergistic effectiveness of these compounds with acetone as attractants for mosquitoes.

Table 3

Results of screening for compounds with a mode of action similar to lactic acid are below (also called "base" compounds for "base attractants"):

Compound	Response (%)	Response with Ace (%)	Δ [(Resp with Ace) - Resp] (%)
L-lactic acid	26 (see above)	*88* (see above)	62
D-lactic acid	8	*82*	74
glycolic acid	17	*81 81*	64
tartaric acid	9	*67*	58
thiolactic acid	4	*68*	64
3-hydroxy-2-butanone	9	*57*	48
butanal	6	7	1
isoprene	12	*56*	44
1-heptene	4	34	30
1-octene	38	*63*	25
1-nonene	6	*54*	48

Ace=acetone

Example 4

Table 4 illustrates the effectiveness of humans for attracting *Aedes aegypti* mosquitoes. Data were collected from September 1997 - June 1998.

Table 4

Human subjects tested in the olfactometer (raw data, % attraction):

D. Kline	72 83 74 85 78 81 68 86	Avg:	*78%*
K. Posey	70 67 55 79 78	Avg:	*70%*
U. Bernier	83 63 68 55	Avg:	*67%*

Example 5

Table 5 illustrates the effectiveness of several compositions as attractants for mosquitoes.

Table 5

Various mixtures and items examined, and described containers:

9-spot well plates with <10 µL pure L-LA + 500 µL acetone	*95%*
LA + acetone (four 8.9 mm diam. caps)	*95%*
Dish: LA + chloroform Cap: 90:10	*95%*
Dish: LA + CS_2 + chloroform; Cap to 20 ml scintillation vial: 90/10	*94%*
LA + acetone (two 8.9 mm diam. caps)	*94%*
LA + acetone + 100 µL methylene chloride	*93%*
LA + acetone + ethanol	*92%*
LA + acetone (one 8.9 mm diam. cap) - max 400 µL acetone per cap	*92%*
LA + 300 µL 1-octene + acetone	*92%, 89%*
500 µL acetone (dish 1) + 200 µg LA (dish 2)	*91%*
500 µL (75:25) + 200 µg LA	*90%*
LA + acetone + 2-butanone	*89%*
LA + acetone + 100 µL CS_2	*89%*
LA + isoprene (8.9 mm diam. cap)	*88%*
LA + acetone + 50 µL 3-pentanone	*88%*
500 µL (90:10) acetone/dmds + 200 µg LA	*88%*
9-spot well plate with equal amounts of AM1 components + LA	*88%*
LA + 75:25 + acetonitrile	*87%*
Dish: LA + CS_2 Cap: 90:10	*87%*
9-spot well plate with LA (wet) + acetone	*86%*

266 ng glycolic acid + 1 ml acetone	*86%*
500 µL AM1 + 200 µg LA	*85%*
9-spot well plates with LA (wet) + 2 wells acetone	*83%*
LA + acetone + 100 µL butanone	*80%*
500 µL (50:50) + 200 µg LA	*79%*
LA + acetone + 100 µL acetonitrile	*78%*
9-spot well plates with 10 µL thiolactic acid + 2 wells acetone	*73%*
D. Kline 4-day old worn sock	*71%*
LA + 2-octanone + acetone	*68%*
500 µL AM1	*47%*
266 µg glycolic acid + LA dried 3 min	*45%*
LA + 5-nonanone + acetone	*44%*
Acetonitrile + tartaric acid	*41%*
500 µL (90% acetone + 10% dimethyl disulfide)	*35%*
500 µL (75:25) acetone/dmds	*33%*
500 µL (50:50) acetone/dmds	*24%*
1-hepten-3-ol	*7%*

90:10, 75:25, and 50:50 refer to the ratio of acetone to dimethyl disulfide in the mixture.

LA = lactic acid

The default treatment for LA is 200 µg and for other chemicals, it is 500 µL of the compound, unless specified otherwise.

The scintillation vial cap (1W) has an inner diameter of 13.5 mm. The black autosampler (1B) vial caps have an inner diameter of 8.9 mm and can hold approximately 400 µL of liquid.

AM1 = attractant mixture 1 is formulated as follows: 100 ml acetone, 700 µL butanone, 5 µL 3-methyl-2-butanone, 10 µL 2-pentanone, 300 µL carbon disulfide, 10 µL dimethyl sulfide, 10 µL dimethyl disulfide, and 500 µL acetonitrile.

Example 6

Table 6 illustrates the average values for the effectiveness of several compounds and combinations of compounds as attractants for *Aedes aegypti*. These data were obtained from formal screenings and formal randomized tests.

Table 6
Average Values for Compounds and Compositions
Tested for Attraction of *Aedes aegypti*

W=White Cap, ~1200 uL volume, B=Black Cap, ~400 uL volume, but omission rate determined by exposed surface area, temperature, and chemical volatility. I=Insert, ~225 uL volume. Numerical Doses have Units of ug for solids or uL for liquids--Numerical Entries without letter designation indicate experiments in a 60 mL glass petri dish. Doses without units are typically µg for bases and µL for activators. Crys denotes a solid with 500 µg-2 mg sample mess. Data compiled only from "formal" screen tests and experiments with randomized design.

Base	Dose	Activator1	Dose	Activator 2	Dose	Response Avg %	Number of Tests
LA	600	Acetone	500			96.9%	
LA	50W	Acetone	1B			96.4%	
LA	20W	Acetone	1B			94.9%	
LA	50W	Dimethyl Disulfide	1W			93.3%	
LA	200W	1,1,1-Trichloroethane	4B			92.5%	
LA	200	Carbon Tetrachloride	500			92.0%	
LA	400	Acetone	1000			91.8%	n=3
		Carbon Tetrachloride	500			91.5%	
LA	600	Acetone	1000			91.1%	n=2
LA	100W	Acetone	1W			91.0%	
LA	50W	Methylene Chloride	1I			90.8%	

Base	Dose	Activator1	Dose	Activator 2	Dose	Response Avg %	Number of Tests
LA	200	Acetone	500	Nitrogen	50	90.3%	
LA	200W	Acetone	500			90.2%	
LA	200	Acetone	375	Dimethyl Disulfide	125	90.0%	
LA	400	Acetone	500			89.5%	n=3
LA	10W	Acetone	1B			89.4%	n=2
LA	support	Acetone	1500			89.3%	n=2
LA	200	Acetone	1W			89.2%	
LA	200	Carbon Disulfide	500			89.0%	
Glycolic Acid	crys	Acetone	1B			88.5%	
LA	200	Acetone	450	Dimethyl Disulfide	50	88.0%	
LA	100W	Acetone	2B			87.7%	
LA	50 uL W	Acetone	2B	Pyruvic Acid	50 uL W	87.7%	
LA	200	Acetone	500			87.6%	n=8
LA	10W	Acetone	1W			87.4%	
LA	200W	Carbon Tetrachloride	1B			87.0%	
		Methylene Chloride	500			87.0%	
LA	100W	Acetone	4B			86.6%	
LA	50W	Dimethyl Disulfide	1B			86.6%	
LA	50W	Methylene Chloride	1W			86.5%	
LA	200W	Carbon Dioxide	40 mL/min			86.0%	n=3
LA	2W	Acetone	1W			85.9%	

Base	Dose	Activator1	Dose	Activator 2	Dose	Response Avg %	Number of Tests
LA	200	Dimethyl Disulfide	500			85.5%	
LA	200W	Trichloroethylene	4B			85.5%	
LA	400W	Acetone	4B			85.1%	
LA	200	AM1	500			85.0%	
LA	200	Acetone	1000			84.9%	n=26
LA	50W	Carbon Disulfide	1B			84.7%	
LA	200W	Methylene Chloride	4B			83.7%	n=3
LA	100W	Acetone	1B			83.3%	n=2
LA	50W	Carbon Disulfide	1W			82.9%	
LA	50W	Methylene Chloride	1B			82.7%	
D-LA	200	Acetone	500			82.4%	
LA	200	3-Methyl-2-Butanone	500			82.0%	
LA	200	Acetone	500	Glycolic Acid	266	82.0%	
		Carbon Disulfide	500			82.0%	
LA	400W	Acetone	2B			81.6%	
LA	2W	Methylene Chloride	1W			81.3%	
LA	200W	Dimethoxymethane	1B			81.1%	
Glycolic Acid	266	Acetone	500			81.0%	
LA	200	Acetonitrile	500			81.0%	
LA	200	Butanone	500			81.0%	
LA	200W	Butanone	2B			80.7%	n=3

Base	Dose	Activator1	Dose	Activator 2	Dose	Response Avg %	Number of Tests
		Methylene Chloride	1W			79.8%	n=2
Hand-L DK						79.5%	n=5
LA	2W	Acetone	1B			79.2%	
LA	200	Acetone	250	Dimethyl Disulfide	250	79.0%	
LA	200	Dimethyl suflide	500			79.0%	
3-Hydroxy-2-Butanone	500	Acetone	500			78.0%	
LA	200W	Acetone	4B			77.6%	n=13
LA	200W	Methylene Chloride	1B			76.8%	n=79
LA	200W	Trichloroacetonitrile	1B			76.8%	
LA	50 uL W	Acetone	4B	Pyruvic Acid	50 uL W	76.7%	
Hand-L KP						76.6%	n=4
LA	200W	Chloroform	1B			76.3%	n=4
LA	200W	Dimethyl Disulfide	1W			76.3%	n=3
LA	200W	Isoprene	4B			76.3%	n=3
LA	200W	Dimethyl Disulfide	1B			76.1%	n=80
LA	200	2-Pentanone	500			76.0%	
LA	200	Chloroform	500			76.0%	
LA	200W	Methylene Chloride	1000			75.9%	n=3
LA	200W	Acetone	1W			75.0%	n=108
LA	200W	Thiophene	1B			74.6%	

Base	Dose	Activator1	Dose	Activator 2	Dose	Response Avg %	Number of Tests
Hand-L UB						72.6%	n=25
LA	200W	Tetrachloroethylene	4B			72.1%	
LA	200W	Chloroform	2B			71.4%	n=4
LA	200W	Chloroform	4B			70.7%	n=3
LA	200	Methylene Chloride	500			70.0%	
LA	200W	Acetone	1B			69.6%	n=32
LA	400W	Acetone	1B			69.4%	
Hand-R KP						69.2%	n=5
LA	200W	Acetone	2B			68.6%	n=12
LA	200W	2-Hexanone	1B			68.0%	
LA	200W	Methylene Chloride	2B			68.0%	n=3
Thiolactic Acid	100 uL	Acetone	500			68.0%	
LA	2W	Dimethyl Disulfide	1W			67.2%	
LA	200	Dimethyl Trisulfide	500			67.0%	
Tartaric Acid	180	Acetone	500			67.0%	
LA	200W	Isoprene	1B			66.8%	n=5
LA	200W	Butanone	1B			66.2%	n=4
LA	200W	Butanone	4B			66.1%	n=3
LA	200	CO2	0.5	mL/min Air	50 mL/min	66.0%	n=2
LA	200	MeOH	500			66.0%	

Base	Dose	Activator1	Dose	Activator 2	Dose	Response Avg %	Number of Tests
LA	50W	Acetone	1I	Dimethyl Disulfide	1I	64.9%	
LA	200W	Carbon Disulfide	2B			64.8%	n=3
LA	200	4-Methyl-2-Pentanone	500			64.0%	
LA	200	Bromoform	500			64.0%	
LA	200W	Acetone	1I	Glycolic Acid	crys-W	63.9%	
LA	2W	Methylene Chloride	1I			63.5%	
LA	50W	Acetone	1I			63.3%	
LA		Phenylacetonitrile	500			63.0%	
		Acetone	500	1-Octene	500	63.0%	
LA	200W	Dimethyl Disulfide	2B			62.3%	n=3
LA	2W	Methylene Chloride	1B			62.3%	
LA	50W	Dimethyl Disulfide	1I	Carbon Disulfide	1I	61.4%	
LA	2W	Acetone	1I			61.3%	
LA	10W	Methylene Chloride	1I			61.2%	
LA	200W	1,1,2-Trichloroethane	4B			59.1%	
LA	200	Toluene	500			59.0%	
		Methylene Chloride				58.9%	
LA	200W	Carbon Disulfide	1B			58.8%	n=4
LA	200W	Isoprene	1B	2-Hexanone	1B	58.0%	
LA	2W	Dimethyl Disulfide	1I			57.0%	
LA	100W	Acetone	1I			56.8%	

Base	Dose	Activator1	Dose	Activator 2	Dose	Response Avg %	Number of Tests
Pyruvic Acid	50 uL	Acetone	4B			56.7%	
		Acetone	500	Nitrogen	50	56.5%	
LA	200W	Carbon Disulfide	4B			56.2%	n=4
LA	200W	Acetone 90:10	1B	Dimethyl Disulfide 10:90	1B	56.0%	
LA	200	Diethyl Ether	500			56.0%	
		Acetone	500	Isoprene	500	56.0%	
		Acetone	500			55.8%	n=3
LA	200	Ethanol	500			55.0%	
LA	200	Ethylvinyl Sulfide	500			55.0%	
		Methylene Chloride	4B			54.3%	n=3
LA	50W	Acetone	2I			54.2%	
LA	100W					54.1%	
LA	200	Diethyl Sulfide	500			54.0%	
LA	50W	Acetone	1I	Carbon Disulfide	1I	53.2%	
LA	200W	Furfuryl Alcohol	1B			52.8%	
LA	200W	Dimethyl Disulfide	4B			52.7%	n=3
		Chloroform	2B			52.6%	n=3
LA	200W	Phorone	1B			52.2%	
LA	200	2-Methylfuran	500			52.0%	
LA	200W	6-Methyl-5-Hepten-2-one	1B			52.0%	
LA	200W	Acetone	8I			52.0%	

Base	Dose	Activator1	Dose	Activator 2	Dose	Response Avg %	Number of Tests
LA	200	2-Hexanone	500			51.0%	
LA	200	3-Penten-2-one	500			49.0%	
LA	200	Diethyl Disulfide	500			49.0%	
LA	200W	Acetone	2I			48.0%	
LA	200	Benzonitrile	500			48.0%	
LA	200	5-Nonanone	500			47.0%	
LA	200W	Acetone	4I			47.0%	n=2
		AM1	500			47.0%	
LA	200	Acetophenone	500			46.0%	
LA	200	Linalool	500			46.0%	
		Dimethyl Disulfide	1W			46.0%	n=2
		Methylene Chloride	2B			46.0%	n=3
LA	200W	2,3-Butanedione	1B			45.8%	n=4
LA	10W	Dimethyl Disulfide	1I			45.2%	
LA	200W	Acetone	1B	2,3-Butanedione	1B	45.0%	
LA	200	Glycolic Acid	266			45.0%	
LA	200W	Dimethoxymethane	1I			44.4%	
LA	200W	Methyl Butyrate	1B			43.1%	
LA	200W	Acetone	1I			43.0%	
LA	50W	Carbon Disulfide	1I			42.7%	
LA	200	1-Octene	500			42.0%	

Base	Dose	Activator1	Dose	Activator 2	Dose	Response Avg %	Number of Tests
LA	200	2-Heptanone	500			42.0%	
LA	200W	Dimethyl Trisulfide	1B			41.0%	
Tartaric Acid	180	Acetonitrile	500			41.0%	
LA	200W	Isoprene	2B			40.5%	n=4
		Chloroform	4B			40.2%	n=3
LA	200W	3-Buten-2-one	1B			40.0%	
LA	200	Methylpropyl Disulfide	500			40.0%	
LA	50W	Acetone	3I			39.1%	
DL-Mandelic Acid	crys	Acetone	500			39.0%	
LA	200	3-Buten-2-one	500			39.0%	
LA	200	3-Hexanone	500			39.0%	
LA	200W	3-Pentanone	1B			39.0%	
		Chloroform	1B			39.0%	n=3
		Acetone	4B			38.3%	n=8
		1-Octene	500			38.0%	
		2,3-Butanedione	500			37.0%	
LA	200W	1-Methylpyrrole	1B			36.8%	
		2,3-Butanedione	2B			36.3%	n=3
		Methylene Chloride	1B			36.3%	n=79
LA	200	3-Heptanone	500			36.0%	

Base	Dose	Activator1	Dose	Activator 2	Dose	Response Avg %	Number of Tests
LA	200W	3-Hexanone	1B			36.0%	
		Dimethyl Disulfide	500			36.0%	
LA	10W	Acetone	1I			35.2%	n=2
LA	200	3-Hydroxy-2-Butanone	500			35.0%	
		Acetone	450	Dimethyl Disulfide	50	35.0%	
		Acetone	1W			34.6%	n=54
LA	2W	Dimethyl Disulfide	1B			33.8%	
		Carbon Disulfide	4B			33.2%	n=4
		Acetone	375	Dimethyl Disulfide	125	33.0%	
		Diethyl Disulfide	500			33.0%	
LA	200	FC43	500			32.3%	
		Butanone	2B			32.1%	n=3
LA	200	4-Heptanone	500			32.0%	
LA	200	Isobutanal	500			32.0%	
LA	200	p-Cresol	500			32.0%	
		Dimethyl Sulfide	500			32.0%	
		Linalool	500			32.0%	
LA	200	1,1,3-Trichloroacetone	500			31.7%	
		3-Buten-2-one	500			31.0%	
Pyruvic Acid	50 uL					30.7%	
LA	200	Dimethylsulfoxide	500			30.0%	

Base	Dose	Activator1	Dose	Activator 2	Dose	Response Avg %	Number of Tests
LA	200	2,3-Butanedione	500			29.0%	
LA	200	Acetaldehyde	500			29.0%	
LA	200W	Acetaldehyde	1B			29.0%	
LA	200W	Acetonitrile	4B			29.0%	n=3
		Dimethoxymethane	1I			29.0%	
		2,3-Butanedione	1B			28.7%	n=3
LA	200	3-Pentanone	500			28.0%	
		Butanone	500			28.0%	
		Furfuryl Alcohol	500			28.0%	
LA	50W	Dimethyl Disulfide	1I			27.6%	
		Acetone	1B			27.2%	n=26
LA	200	6-Methyl-5-Hepten-2-one	500			27.0%	
LA	200					27.0%	n=54
		Acetonitrile	500			27.0%	
		Bromoform	500			27.0%	
		Acetone	2B			26.9%	n=6
		Methyl Butyrate	500			26.8%	
		Butanone	4B			25.9%	n=3
Glycolic Acid	crys-W					25.3%	
LA	200W	Acetonitrile	2B			25.0%	n=3
		Diethyl Ether	500			25.0%	

Base	Dose	Activator1	Dose	Activator 2	Dose	Response Avg %	Number of Tests
LA	200W	2,3-Butanedione	2B			24.0%	n=3
LA	200	2-Decanone	500			24.0%	
		Acetone	250	Dimethyl Disulfide	250	24.0%	
		Chloroform	500			24.0%	
Glycolic Acid	crys-W	Acetone	1I			23.8%	
LA	200	1-Penten-3-one	500			23.0%	
LA	200	Isoprene	500			23.0%	
		2,3-Butanedione	4B			23.0%	n=3
Thiourea	crys	Acetone	1W			22.6%	
		Dimethyl Disulfide	1B			22.4%	n=80
LA	200W	2,3-Butanedione	4B			22.0%	n=3
LA	200	Nonanal	500			21.5%	n=2
		Carbon Disulfide	1B			21.5%	n=3
		Acetone	1I			21.4%	
LA	200	Benzaldehyde	500			21.0%	
		Dimethyl Trisulfide	500			21.0%	
		Dimethoxymethane	1B			20.3%	
Indole	500 mg	Acetone	500			20.0%	
LA	200W	3,4-Hexanedione	4B			20.0%	
LA	200W	3-Penten-2-one	1B			20.0%	
LA	200	1-Heptene	500			19.0%	

Base	Dose	Activator1	Dose	Activator 2	Dose	Response Avg %	Number of Tests
		1-Penten-3-one	500			19.0%	
		Methylpropyl Disulfide	500			19.0%	
LA	50 uL W	Pyruvic Acid		50 uL W		18.9%	
LA	200W	Acetonitrile	1B			18.8%	n=4
		Carbon Disulfide	2B			18.4%	n=4
D-LA	200					18.1%	
		Ethylvinyl Sulfide	500			18.0%	
		Methyl Butyrate	1B			17.1%	
Glycolic Acid	266					17.0%	
LA	200W	2,3-Hexanedione	4B			17.0%	
		2-Heptanone	500			17.0%	
		4-Heptanone	500			17.0%	
		Acetone	500	Propanoic acid	500	17.0%	
LA	2W					16.8%	n=3
LA	200W	5-Methyl-2-Hexanone	1B			16.4%	
		Dimethyl Disulfide	4B			16.3%	n=3
LA	200W			Glycolic Acid	crys-W	16.2%	
		Isoprene	2B			16.1%	n=3
LA	200	2-Octanone	500			16.0%	
		Phenylacetonitrile	500			16.0%	
LA	200W					15.8%	n=195

Base	Dose	Activator1	Dose	Activator 2	Dose	Response Avg %	Number of Tests
		2-Methylfuran	500			15.0%	
		Diethyl Sulfide	500			15.0%	
		Dimethyl Disulfide	2B			14.7%	n=3
		2-Decanone	500			14.0%	
		5-Nonanone	500			14.0%	
		Isoprene	4B			13.6%	n=3
2-Amino-pyridine	500 mg	Acetone	500			13.2%	
LA	200W	1-Penten-3-one	1B			13.0%	
		Isobutanal	500			13.0%	
LA	200	2-Nonanone	500			12.0%	
LA	200W	Isobutanal	1B			12.0%	
		3-Heptanone	500			12.0%	
		3-Pentanone	500			12.0%	
		Isoprene	500			12.0%	
		Isoprene	1B			11.8%	n=3
3-Hydroxy-2-Butanone	500					11.0%	
		3-Penten-2-one	500			11.0%	
		Nonanal	500			11.0%	
		Methylene Chloride	1I			10.1%	

Base	Dose	Activator1	Dose	Activator 2	Dose	Response Avg %	Number of Tests
LA	200W	5-Methyl-3-hexen-2-one	1B			10.0%	
		MeOH	500			10.0%	
		Nonanal	500			10.0%	
DL-Malic Acid	crys	Acetone	1W			9.3%	
		Butanone	1B			9.3%	n=4
LA	200	2-Methyl-3-Pentanone	500			9.0%	
LA	200	3-Methyl-2-Pentanone	500			9.0%	
LA	200	3-Nonanone	500			9.0%	
Tartaric Acid	180					9.0%	
		6-Methyl-5-Hepten-2-one	500			9.0%	
		Acetophenone	500			9.0%	
		Benzaldehyde	500			9.0%	
		Ethanol	500			9.0%	
		Acetonitrile	4B			8.7%	n=3
		1,4-Diaminobutane	1B			8.6%	
LA	200W	6-Methyl-3,5-Heptadien-2-one	1B			8.2%	
		Dimethyl Disulfide	1I			8.1%	
LA	200	1-Nonene	500			8.0%	
		2-Nonanone	500			8.0%	
		2-Octanone	500			8.0%	

Base	Dose	Activator1	Dose	Activator 2	Dose	Response Avg %	Number of Tests
		2-Pentanone	500			8.0%	
		3-Methyl-2-Butanone	500			8.0%	
		3-Methyl-2-Pentanone	500			8.0%	
		Acetaldehyde	500			8.0%	
LA	200	Butanal	500			7.0%	
		Acetone	500	Butanal	500	7.0%	
		Toluene	500			7.0%	
Succinic Acid	crys	Acetone	1W			6.9%	
LA	200W	4-Hexen-3-one	1B			6.7%	
		1-Nonene	500			6.0%	
		Butanal	500			6.0%	
		Furfuryl Alcohol	1B			5.4%	
LA	200	Formaldehyde	500			5.0%	
		1-Heptene	500			5.0%	
		p-Cresol	500			5.0%	
Glyoxylic Acid	100 uL	Acetone	1W			4.9%	
LA	200W	1-Octen-3-one	1B			4.6%	
Thiolactic Acid	100 uL					4.0%	
		3-Nonanone	500			4.0%	
		Benzonitrile	500			4.0%	

Base	Dose	Activator1	Dose	Activator 2	Dose	Response Avg %	Number of Tests
		CO2	0.5			4.0%	
LA	200W	4-Decanone	1B			3.2%	
		2-Hexanone	500			3.0%	
		Dimethylsulfoxide	500			3.0%	
		Propanoic acid	500			3.0%	
		Acetone	1I			2.9%	
LA	200W	2-Methyl-3-Octanone	1B			2.5%	
		Acetonitrile	2B			2.3%	n=3
LA	200W	Diethyl Phthalate	1B			1.5%	
LA	200W	1,4-Diaminobutane	1B			1.4%	
LA	200W	Butanal	1B			1.0%	
LA	200	Propanoic acid	500			1.0%	
		2-Methyl-3-Pentanone	500			1.0%	
		3-Hexanone	500			1.0%	
		Acetonitrile	1B			1.0%	n=3
		Formaldehyde	500			1.0%	
LA	200W	E-3-Nonen-2-one	1B			0.0%	
		4-Methyl-2-Pentanone	500			0.0%	

Example 7

Table 7

Compounds and Compositions Tested for Attraction of *Aedes albopictus*

Treatment	% caught
Glycolic Acid Crys./CO2 5 mL/min	65.8
DLK-R Sock, 1 day old	*64.4*
DLK-L Hand/CO2 (5 mL/min)	*60.6*
LA 200 µg/CO2 5mL/min	57.5
DLK-L Hand	*55.6*
LA 200 µg/Glycolic Crys./CO2 5 mL/min	50.6
DLK-L Hand	*49.3*
DLK-L Hand	*45.8*
LA 200 µg/CO2 5mL/min	45.2
Treatment	% caught
LA 200 µg/CS2 1B/CO2 5mL/min	44.9
LA 200 µg/CO2 5mL/min	42.7
LA 200 µg/Acetone 1B/CO2 5mL/min	40.3
LA 200 µg/DMDS 1B/CO2 5 mL/min	36.9
LA 200 µg/CCl4 1B/CO2 5mL/min	35.1
CO2 5mL/min	34.6
LA 200 µg/CS2 500 µL Dish	33.8
LA 200 µg/Chloroform 1B	33.8
LA 200 µg/2,3-Butanedione 1B/MeCl2 1B	33.3
LA 200 µg/MeCl2 1B/CO2 5mL/min	32.9
LA 200 µg/CCl4 1B/MeCl2 1B	32.9
CO2 5mL/min	32.0
CO2 5mL/min (water immersed)	29.2
DL-Mandelic Acid Crys./Thiophene 1B	27.8
LA 200 µg/2,3-Butanedione 500 1B	27.6
LA 200 µg/Thiophene 1B	27.0
Glycolic Acid Crys./Thiophene 1B	26.8
LA 200 µg/Acetone 1B/CO2 5mL/min	24.1
CO2 5mL/min	23.0
LA 200 µg/CS2 1B/MeCl2 1B	22.7
LA 200 µg/CS2 1B/MeCl2 1B	22.2
LA 200 µg/MeCl2 500 µL Dish	19.4
LA 200 µg/DMDS 1B/CO2 5 mL/min	16.2
LA 200 µg/Thiophene 500 µL Dish	15.7
LA 200 µg/Acetophenone 1B	15.1
Mushrooms from DLK Yard	13.7
Garlic clove	13.7
LA 200 µg/Phenylacetonitrile 1B	12.5
LA 200 µg/Ethylvinyl Sulfide 1B	12.5
LA 200 µg/CS2 1B/2,3-Butanedione 1B	12.0
LA 200 µg/CCl4 1B	12.0
LA 200 µg/Diethyl Sulfide 1B	11.9

LA 200 µg	11.7
LA 200 µg/Benzaldehyde 1B	11.6
LA 200 µg/Acetone 500 uL Dish	11.1
CO2 5mL/min	11.1
LA 200 µg/Ethyl Acetate 1B	10.8
3-Hydroxy-2-Butanone 1B/Thiophene 1B	10.8
Glyoxylic Acid 1 mL Dish/Thiophene 1B	10.4
CO2 5mL/min (water immersed)	9.7
LA 200 µg/2,3-Butanedione 1B/CO2 5mL/min	9.5
Acetone 500 µL Dish	9.1
CS2 500 µL Dish/MeCl2 500 µL Dish	8.9
LA 200 µg	8.3
LA 200 µg/Isoprene 1B	8.1
LA 200 µg/2,3-Butanedione 500 µL Dish	8.1
Mixture F1 1B	7.6
LA 200 µg/Thiourea Crys. Dish	7.6
LA 200 µg/Benzonitrile 1B	7.6
LA 200 µg/CS2 1B	7.1
LA 200 µg/1,1,2-Trichloroethane 1B	7.0
Limburger Cheese (European)	6.8
LA 200 µg/1-Octen-3-ol 1B	6.8
DL-Malic Acid Crys./Thiophene 1B	6.8
CO2 5mL/min	6.8
1,4-Diaminobutane 1B	6.8
LA 200 µg/Nitromethane 1B	6.6
LA 200 µg/Pyrazine 1B	6.4
LA 200 µg/2-Nonanone 1B	6.4
LA 200 µg/3-Nonanone 1B	6.3
LA 200 µg/2-Hexanone 1B	6.3
LA 200 µg/4-Hexen-3-one 1B	5.5
Mixture F2 1B/Butanal 1B/CS2 1B	5.3
LA 200 µg/Methylbutyrate 1B	5.3
Mixture F2 1B/Butanol 1B/CS2 1B	5.1
LA 200 µg/CS2 1B/DMDS 1B/Acet 1B	4.7
LA 200 µg/1-Butanol 1B	4.6
Pyruvic 1B/Thiophene 1B	4.5
LA 200 µg/2-Methylfuran 1B	4.2
LA 200 µg/2,3-Hexanedione 1B	4.2
LA 200 µg/1-Nonanal 1B	4.2
LA 200 µg/Nonanal 500 µL Dish	4.1
LA 200 µg/3-Methyl-2-Pentaone 1B	3.9
LA 200 µg/2-Pentanone 1B	3.9
LA 200 µg/2-Decanone 1B	3.8
LA 200 µg/4-Heptanone 1B	3.7
LA 200 µg/1-Methylpiperazine 1B	3.7
LA 200 µg/CS2 1B/DMDS 1B	3.5
LA 200 µg/50:50 Acetone:DMDS 1B	2.7
LA 200 µg/3-Methyl-2-Butanone 1B	2.7
LA 200 µg/3-Buten-2-one 1B	2.7
LA 200 µg/2-Octanone 1B	2.7
LA 200 µg/Diethyl Disulfide 1B	2.6
LA 200 µg/Acetonitrile 1B	2.6
LA 200 µg/6-Methyl-5-Hepten-2-one 1B	2.6
LA 200 µg/DMDS 500 µL Dish	2.4

LA 200 µg/Toluene 1B	1.5	LA 200 µg/Butanal 1B	1.3
LA 200 µg/Methylpropyl Disulfide 1B	1.4	LA 200 µg/5-Nonanone 1B	1.3
LA 200 µg/3-Heptanone 1B	1.4	LA 200 µg/1-Hexen-3-ol 1B	1.3
LA 200 µg/2-Methyl-3-Pentanone 1B	1.4	LA 200 µg/1,4-Diaminobutane	1.3
LA 200 µg/2-Heptanone 1B	1.4	LA 200 µg/Thiolactic Acid 1B	0.0
LA 200 µg/2,4-Pentanedione 1B	1.4	LA 200 µg/3,4-Hexanedione 1B	0.0
CO2 5mL/min (water immersed)	1.4		

Key to abbreviations in Table: LA=L-Lactic Acid, CS2=Carbon Disulfide, MeCl2=Methylene Chloride=Dichloromethane, DMDS=Dimethyl Disulfide, CCl4=Carbon Tetrachloride, Crys.=Crystalline Solid, 1B=1 Black cap of approx. 400 mL volume, DLK=Dan Kline, -L=left hand or left sock, -R=right hand or right sock

Example 8

Table 8

Compounds and Compositions Tested for Attraction of *Anopheles albimanus*

Treatment	% caught
LA 200 μg/MeCl2 500 μL dish	97.4
DMDS 500 μL	97.3
LA 200 μg/DMDS 500 μL dish	92.5
LA 200 μg/MeCl2 1B	92.0
Dimethyl Trisulfide 500 μL	91.8
LA 200 μg/Acetone 500 μL dish	91.7
LA 200 μg/Acetone 500 μL dish	89.9
LA 200 μg/Acetone 500 μL dish	83.0
4-Hexen-3-one 500 μL	79.2
Chloroform 500 μL	78.7
LA 200 μg/MeCl2 1B	77.6
MeCl2 500 μL	75.7
CCl4 500 μL	74.0
Dimethyl Sulfide 500 μL	68.4
Thiophene 500 μL	68.0
Trichloroacetonitrile 500 μL	65.3
1,1,2-Trichloroethane 500 μL	64.4
MeCl2 1B	64.4
MeCl2 1B	63.0
LA 200 μg/Thiophene 1B	62.7
1,1,1-Trichloroethane 500 μL	61.0
LA 200 μg/MeCl2 1B	58.7
Trichloroethylene 500 μL	57.9
LA 200 μg/Acetone 500 μL dish	57.0
CS2 500 μL	56.0
Methylbutyrate 500 μL	55.8
3-Pentanone 500 μL	53.9
Phorone 500 μL	50.6
DMDS 1B	49.3
LA 200 μg/MeCl2 1B	48.6
Butanone 500 μL	47.9
Furfuryl Alcohol 500 μL	46.7
3-Buten-2-one 500 μL	45.2
LA 200 μg/DMDS 1B	44.7
LA 200 μg/CS2 1B	42.7
Ethanethiol 500 μL	40.0
LA 200 μg/Chloroform 1B	39.5
DMDS 1B/Thiophene 1B	37.8
2-Methylfuran 500 μL	35.5
Benzaldehyde 500 μL	35.5
2-Methyl-3-Heptanone 500 μL	34.7
Diethyl Sulfide 500 μL	33.3

LA 200 µg/Dimethyl Sulfide 1B	32.4
LA 200 µg/CCl4 1B	32.0
DMDS 1B	31.5
2-Methyl-3-Octanone 500 µL	30.1
Acetone 500 µL	29.6
p-Cresol 500 µL	29.5
1-Penten-3-one 500 µL	29.3
Pyrazine 500 µL	29.3
2-Octanone 500 µL	28.6
Ethyl Acetate 500 µL	28.4
Mesityl Oxide 500 µL	28.4
DMDS 1B	28.0
DMDS 1B	27.4
2-Nonanone 500 µL	27.0
LA 200 µg/DMDS 1B	26.9
F1 Mixture 500 µL	26.4
6-Methyl-5-Hepten-2-one 500 µL	26.0
Butanone 1B/Thiophene 1B	26.0
Ethylvinyl Sulfide 500 µL	25.4
3-Octanone 500 µL	25.0
3-Methyl-2-Butanone 500 µL	24.4
1-Octen-3-ol 500 µL	24.0
1-Propanethiol 500 µL	24.0
Butanone 1B/DMDS 1B	22.7
Nitromethane 500 µL	22.1
LA 200 µg/5-Nonanone 1B	21.1
2-Thiopropane 500 µL	20.5
DMDS 1B	20.5
2,4-Pentanedione 500 µL	19.4
2,6-Dimethyl-4-Heptanone 500 µL	18.7
6-Methyl-3,5-Heptadien-2-one 500 µL	18.7
3,4-Hexanedione 1B/Methylbutyrate 1B	17.9
Nitromethane 500 µL	17.3
Tetrachloroethylene 500 µL	17.3
3-Methyl-2-Pentanone 500 µL	17.1
LA 200 µg/3-Buten-2-one 1B	17.1
LA 200 µg/Butanone 1B	16.0
3-Nonanone 500 µL	15.8
LA 200 µg/2-Thiopropane 1B	15.8
LA 200 µg/4-Hexen-3-one 1B	14.7
Toluene 500 µL	13.5
Isophorone 500 µL	13.3
LA 200 µg/Acetone 1B	13.3
LA 200 µg/2-Methylfuran 1B	13.0
5-Nonanone 500 µL	12.7
Methylpropyl Disulfide 500 µL	12.3
Acetone 1B	12.2
4-Hexen-3-one 1B/Thiophene 1B	12.0
LA 200 µg/1-Methylpyrrole 1B	12.0
LA 200 µg/p-Cresol 1B	12.0
5-Methyl-3-Hexen-2-one 500 µL	11.8
5-Methyl-2-Hexanone 500 µL	11.7
3-Heptanone 500 µL	11.3
2-Pentanone 500 µL	10.8

1-Methylpyrrole 500 µL	10.7
5-Methyl-3-Hexen-2-one 500 µL	10.7
Acetone 1B	10.7
DMDS 1B/4-Hexen-3-one 1B	10.7
t-3-Nonen-2-one 500 µL	10.7
3,4-Hexanedione 500 µL	10.5
2-Heptanone 500 µL	10.4
LA 200 µg/Acetone 1B	10.4
3-Decanone 500 µL	9.3
LA 200 µg/Acetone 1B	9.3
LA 200 µg/3-Nonanone 1B	9.2
LA 200 µg/Acetone 1B	9.1
2,4-Pentanedione 500 µL	9.0
LA 200 µg/Benzonitrile 1B	8.9
3-Hexanone 500 µL	8.3
Butanone 1B/4-Hexen-3-one 1B	8.1
LA 200 µg/2-Decanone 1B	8.1
4-Heptanone 500 µL	8.0
Acetophenone 500 µL	7.9
LA 200 µg/Benzaldehyde 1B	7.9
4-Decanone 500 µL	7.8
LA 200 µg/2-Nonanone 1B	6.7
Methyl Urea Crys dish	6.5
1,1,3-Trichloroacetone 500 µL	5.6
2-Methyl-3-Pentanone 500 µL	5.3
LA 200 µg/2-Heptanone 1B	5.3
LA 200 µg/Ethyl Acetate 1B	5.3
Methylbutyrate 1B/5-Methyl-3-Hexen-2-one 1B	5.3
DMDS 1B	5.2
2-Hexanone 500 µL	4.3
2-Undecanone 500 µL	4.2
1-Nonanol 500 µL	4.1
LA 200 µg/Ethylvinyl Sulfide 1B	4.1
2-Decanone 500 µL	4.0
LA 200 µg/2-Pentanone 1B	4.0
LA 200 µg/3-Pentanone 1B	4.0
LA 200 µg/Acetone 1B	4.0
LA 200 µg/Acetophenone 1B	4.0
LA 200 µg/Allyl Disulfide 1B	4.0
Methylbutyrate 1B/Furfuryl Alcohol 1B	4.0
6-Undecanone 500 µL	3.9
LA 200 µg/3-Heptanone 1B	3.9
Benzonitrile 500 µL	3.8
LA 200 µg/2-Octanone 1B	3.8
Diethyl Disulfide 500 µL	2.8
2,3-Hexanedione 500 µL	2.7
Acetic Acid 500 µL	2.7
LA 200 µg/4-Heptanone 1B	2.7
LA 200 µg/Diethyl Sulfide 1B	2.7
LA 200 µg/DMSO 1B	2.7
Pentane 500 µL	2.7
Thiourea Crys dish	2.7
1-Tetradecene 500 µL	1.4
2,3-Butanedione 500 µL	1.4

2-Dodecanone 500 µL	1.4
3,4-Hexanedione 500 µL	1.4
LA 200 µg	1.4
LA 200 µg/4-Methyl-2-Pentanone 1B	1.4
Pyruvic Acid 500 µL	1.4
1-Methylpiperazine 500 µL	1.3
2-Tridecanone 500 µL	1.3
3-Hydroxy-2-Butanone 500 µL	1.3
4-Methyl-2-Pentanone 500 µL	1.3
Butanal 500 µL	1.3
Glutaric Acid Crys dish	1.3
Glycolic Acid Crys dish	1.3
Glyoxylic Acid 500 µL	1.3
Indole 500 µL	1.3
LA 200 µg	1.3
LA 200 µg/3-Hydroxy-2-Butanone 1B	1.3
LA 200 µg/Diethyl Disulfide 1B	1.3
LA 200 µg/Methylpropyl Disulfide 1B	1.3
LA 400 µg dish	1.3
Lauric Acid 500 µL	1.3
Phenylacetonitrile 500 µL	1.3
2-Aminopyridine 500 µL	0.0
Acetonylacetone 500 µL	0.0
Allyl Disulfide 500 µL	0.0
DL-Malic Acid Crys dish	0.0
DL-Mandelic Acid Crys dish	0.0
DMSO 500 µL	0.0
Formic Acid 500 µL	0.0
Isoprene 500 µL	0.0
LA 200 µg	0.0
LA 200 µg/2-Hexanone 1B	0.0
LA 200 µg/2-Methyl-3-Pentanone 1B	0.0
LA 200 µg/3-Hexanone 1B	0.0
LA 200 µg/3-Methyl-2-Butanone 1B	0.0
LA 200 µg/3-Methyl-2-Pentanone 1B	0.0
LA 200 µg/Phenylacetonitile 1B	0.0
LA 200 µg/Toluene 1B	0.0
Succinic Acid Crys dish	0.0
Thiolactic Acid 500 µL	0.0

Example 9

Table 9
Formulation and Verification of the Best Blend
(Note: ~ 10:1 Acetone:DMDS emission rate)

200 µg L-lactic acid (1w)	8%	vs. 200 µg L-lactic acid (1w) + Acetone (3B)	61%
Acetone (3B)	12%	vs. 200 µg L-lactic acid (1w) + Acetone (3B)	59%
200 µg L-lactic acid (1w) + Acetone (3B)	28%	vs. 200 µg L-lactic acid (1w) + Acetone (3B) + DMDS (1B)	47%
200 µg L-lactic acid (1w) + Acetone (B)	42%	vs. 200 µg L-lactic acid (1w) + Acetone (1B) + DMDS (1I)	54%*

* Notes: overall, 95.2% mosquitoes trapped, ~ 30 µL in DMDS (dimethyl disulfide) insert, giving emission of ~ 100:1 Acetone:DMDS.

Example 10

Table 10
Types of Traps

Bed nets
Bates type stable traps
Cylindrical lard can traps
No. 10 Trinidad trap
Trueman & McIver ramp trap
Plexiglas trap
Katô's dry ice trap
DeFoliant & Morris conical trap
Malaise trap
Carbon dioxide light traps
Fay-Prince carbon dioxide trap
Sticky trap
New Jersey light trap
ACIS trap (Army Collapsible Insect Surveillance)
CDC light trap
Kimsey & Chaniotis trap
EVS light trap
Monk's Wood light trap
U.S. Army solid state light trap (AMSS)
Pfuntner light trap

Star beam sticky light trap
Cylindrical light trap
Updraft light traps
"Nozawa" trap
"AS" trap
UV light trap
Flashing light trap
Non-electrical light trap
Haufe & Burgess trap
Fay-Prince trap
Wilton & Kloter cylinder trap
Duplex cone trap
Ikeshoji cylinder sound trap
Ikeshoji & Ogawa cup trap
Kanda et al. cylinder and lantern traps
Heat traps
Sugar-base attraction traps

The synergistic attractant compositions of the present invention may be provided by any number of mechanisms and in different formats appropriate to particular types of usage. The main function of the formats and mechanisms is to provide release of the attractant over a period of time sufficient to attract arthropods (e.g., mosquitoes) effectively, and especially to attract arthropods effectively to an available source of arthropod control material (e.g., insecticide, pheromone, microbial agent) which is effective against mosquitoes, and the like, as described above.

The compositions of the present invention may or may not comprise carbon dioxide. In the embodiment of the present invention wherein the composition does not comprise carbon dioxide, an additional benefit of the present invention is attained. In such an embodiment, highly-efficient, attractive blends for arthropod traps that do not require carbon dioxide are obtained.

An additional benefit of the compositions of the present invention include the obviation for live baits.

The mechanisms and formats will, of course, vary among the various compositions depending on the volatility, persistence, aerial stability, moisture sensitivity, and the like of the individual ingredients and compositions. Moisture,

heat and light may optionally be added to the compounds of the present invention to enhance efficiency. The structures used to release the attractant compositions of the present invention could be as simple as a tray carrying the composition, a housed tray or other container carrying the compositions, timed release canisters or spray cans, absorbent materials retarding the release of the attractant (e.g., fabric, paper, porous material, foam, absorbent polymer, super absorbent polymer [e.g., the super absorbent acrylic polymers as described in U.S. Patent No. 5,679,364], containers with semipermeable membranes, vented containers, and the like). The materials which would more actively attack the arthropods may be associated with the attractant (in a mixture) or may be located near the attractants so the chemicals do not adversely interact or react.

In addition, combining the compositions of the present invention with an insecticide provides a means of local extermination, not requiring wide-disbursement of the insecticide. Addition of a slow release chemical mechanism, such as paraffin, or other suitable viscous chemical (e.g., glycerol) provides a means to reduce the evaporation rates of the compositions.